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THE EFFECTS OF CORPORATE AND COMMUNITY CHARACTERISTICS ON ENVIRONMENTAL POLLUTION IN U.S. ELECTRICAL GENERATING FACILITIES: A MULTILEVEL EXAMINATION

A Dissertation

by

GEORGE EARL TOUCHE´

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2011

Major Subject: Sociology

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Approved by:

Chair of Committee,	Harland Prechel
Committee Members,	Dudley Poston
	Lu Zheng
	George Rogers
Head of Department,	Mark Fossett

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ABSTRACT

The Effects of Corporate and Community Characteristics on Environmental Pollution in U.S. Electrical Generating Facilities: A Multilevel Examination. (August 2011)

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M.S., University of New Orleans;
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Chair of Advisory Committee: Dr. Harland Prechel

This dissertation uses multilevel modeling to examine the effects of corporate and community characteristics on rates of sulfur dioxide emitted by facilities in the electrical power industry. The conceptual framework draws from ecostructural theory to emphasize the social-structural causes of pollution. It also draws from organizational resource dependence theory and the shareholder conception of value. This framework suggests the contemporary transformation in corporate form and the changes in the basic relationship between the corporation and its shareholders have created dependencies, opportunities, and incentives that affect pollution. At the local community level, the conceptual framework also draws from theoretical insights of environmental justice scholars and other scholars in the environmental sociology and social-movement literature. The power plants examined in this dissertation are owned by the largest corporations in the electrical power industry and are located in many different communities across the United States. The multilevel models include three corporate characteristics and four local community characteristics as independent variables. They also include several facility and local community characteristics as control variables. In accordance with ecostructural theory, the findings demonstrate that the total number of subsidiaries in the corporate structure and the dividend payments to shareholders have significant positive effects on the power plant emissions rates. The analysis of community demography shows that relationships involving the power plant emissions rates and percent African Americans, percent families in poverty, and median home values are contingent on the geographic unit of analysis. Hence, the demographic analysis does not consistently support any theory of environmental inequality. On the other hand, all models show that the prevalence of non-profit organizations in the county has a significant negative effect on the power plant emissions rates. This follows in accordance with both ecostructural theory and the path of least resistance theory that underpins the sociopolitical model of environmental inequality. Lastly, all models show that facility control variables involving size, age, and fuel mix have significant effects on the emissions rates. In sum, this dissertation brings together and simultaneously tests theoretical insights from several lines of research to demonstrate that different levels of social structure explain environmental pollution.

DEDICATION

This work is dedicated to George and Naomi Touché.

ACKNOWLEDGMENTS

I thank Harland Prechel in the Sociology Department at Texas A&M University for chairing my committee. I also thank Dudley Poston and Lu Zheng in the Sociology Department at Texas A&M University. Finally, I thank George Rogers in the Department of Landscape Architecture and Urban Planning for serving as the outside committee member on this committee.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION, THEORY, AND LITERATURE

INTRODUCTION

Research on environmental justice has focused on populations that are exposed to pollution by examining the characteristics of communities where hazardous facilities are located. This research has shown that communities with a high proportion of disadvantaged citizens are disproportionately exposed to pollution (Bryant and Mohai 1992; Bullard 1994, 1996, 2001). Researchers in this tradition also find that neither the government nor the legal system has effectively addressed the problem (Bullard, Mohai, Saha, and Wright 2007; Gordon and Harley 2005; Harden 2002).

More recently, researchers began to focus on organizational characteristics as explanations for pollution (Grant, Bergesen, and Jones, 2002). This line of research recognizes that organizations are among the largest polluters in society (Perrow 1997). Research in this tradition has shown that the size of facilities and whether they are embedded in subsidiaries are determinants of pollution rates (Grant et al. 2002; Grant and Jones 2003). Other researchers who examine a wider range of social-structural characteristics and focus on the ultimate parent

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This dissertation follows the style of *American Sociological Review*.

company as the unit of analysis have shown that organizational structure, financial characteristics, and political structure are determinants of pollution rates (Prechel 2009; Prechel and Zheng 2009).

Drawing from these research traditions, this dissertation suggests that research on environmental pollution must examine both levels of analysis. To fill this gap in the literature, I focus on facilities in the high-polluting electrical power industry by using multilevel statistical modeling to address two research questions. First, how do the organizational structure and financial characteristics of large corporations that own power plants affect pollution rates? Second, how do the demographic and social-structural characteristics of local communities where power plants are located affect pollution rates?

This multilevel research is important because environmental sociologists tend to concentrate on only one of these levels of analysis. In contrast, the research herein simultaneously tests the effects of corporate and community characteristics on power plant emissions rates. By grouping power plants owned by a parent company, this method identifies the effects of the corporate characteristics and the community characteristics in the same model; it examines the effects of variables at one level of analysis while controlling for the effects of variables at the other level of analysis.

The basic argument and the recurring theme throughout this dissertation is that organizations matter. The multilevel examination substantiates theoretically and demonstrates empirically that variation in power plant emissions rates is explained by organizational determinants at the corporate level and by organizational deterrents at the local community level. Policy makers, planners, and concerned scientists can use this knowledge to promote sustainable development and ensure that the human population and the natural environment are protected from pollution.

There are five chapters in this dissertation. Chapter I elaborates on the theory and the literature used to derive the conceptual framework. Chapter II specifies the hypotheses. Chapter III discusses the research design including the study group, the variable measures, and the data sources. Chapter III also explicates the structure of the multilevel models with the basic equations used to test the hypotheses. The results and findings are presented in Chapter IV. Finally, Chapter V provides a summary discussion to conclude the dissertation.

THEORY AND LITERATURE

The conceptual framework draws from ecostructural theory. Following Prechel (2009) and Prechel and Zheng (2009), it also draws from theories in organizational and political sociology that suggest the contemporary transformation in corporate form and the changes in the basic relationship between the corporation and its investing shareholders have created dependencies, opportunities, and incentives that affect pollution. At the local community level, the conceptual framework draws from the theoretical insights of environmental justice scholars and related scholars in the environmental sociology and social movement literature. The following sections of this chapter discuss ecostructural theory and other theories in environmental sociology.

Meso-Organizational Level of Analysis: Corporations as a Cause of Pollution

Ecostructural Theory

Ecostructural theory draws from a long line of theories in environmental sociology to emphasize the social-structural causes of pollution (Grant et al. 2002). Much research that may be included under the label ecostructuralism has focused at the macro level of analysis on the effects that social-structural factors such as nation states, modes of production, and world systems have on the environment (Hay 1994; Jorgenson 2003, 2009; Jorgenson, Dick, and Mahutga 2007; O'Connor 1994; Schnaiberg 1980, 1994, 1997). As stressed by Grant et al. (2002), however, it has become difficult to account for how all the different macro structures matter because they typically are far removed from the sites of production where pollution occurs.

Ecostructural theorists therefore have directed attention to organizations and the effects that organizational structures have on the environment (Grant et al. 2002; Grant and Jones 2003; Grant, Jones, and Trautner 2004). These theorists recognize that production techniques are both arranged and implemented within organizations where decision-making power is concentrated and executed. Thus, focusing ecostructural research on organizations can improve knowledge of the social-structural causes of pollution.

Although these theorists have made some valuable contributions, their research agenda on organizational characteristics and pollution is incomplete. Their studies of the chemical industry that show the effects of facility size and subsidiary status on toxic emissions rates focus too narrowly on the polluting facilities without including many other important organizational variables in the analysis (Grant et al. 2002; Grant and Jones 2003). With the exception of firm size, characteristics of the corporations that own the facilities are not included among the explanatory variables. Even the recent work by Grant, Trautner, Downey, and Thiebaud (2010) that draws attention to the conjoint effects of facility characteristics and local community characteristics on chemical plant emissions rates does not examine characteristics of the corporations that own the facilities.

Other theorists have begun to study the effects of a wide range of corporate characteristics on pollution (Prechel forthcoming; Prechel and Zheng 2009). Their elaboration of ecostructural theory draws from several prominent theories in organizational and political sociology to specify how the organizational structure of corporations and their embeddedness in the political-legal environment have created dependencies, opportunities, and incentives that discourage corporations from improving on ecoefficiency. As indicated by Prechel (2009, p. 14), "ecoefficiency reflects the capacity of corporations to create more goods and services with less environmental pollution."

The contributions of these theorists provide both historical contextualization and quantitative analysis that advance knowledge of corporate characteristics as determinants of pollution (Prechel 2009, forthcoming; Prechel and Zheng 2009). These studies explain rates of toxic emissions that are aggregated up to the ultimate parent company. The multilevel examination in this dissertation includes corporate size and two other characteristics. One involves the multilayer-subsidiary form. The other involves shareholder value. These characteristics are discussed in this chapter and then further elaborated in Chapter II.

Capital Dependence and the Incentives and Opportunities for Corporations in the Multilayer-Subsidiary Form to Pollute

Organizational resource dependence theory recognizes the importance of power and uses the concept of embeddedness to explain organizational behavior (Pfeffer and Salanik 1978). Resource dependence theorists argue that organizations are embedded in networks with other organizations and that they are externally constrained and controlled by inter-organizational resource dependencies. These theorists also argue that under certain conditions organizations have opportunities to respond actively by restructuring and by recreating their networks of organizational interdependencies in the environment (Pfeffer and Salanik 1978).

Capital is a special type of resource that corporations depend on for survival (Prechel 1997). Although their response varies with historical conditions, corporations generally respond to capital dependency in two basic ways; they mobilize politically to change the policies of the state, and they transform their structures to better align themselves with the political-legal environment (Boies and Prechel 2002; Prechel 2000). Corporations use a variety of specific mechanisms as they try to cope with uncertainty and establish conditions of stability. Examples include using mergers to acquire other organizations that possess critical resources and using political contributions to influence policies that involve taxes and regulations.

Research on capital dependence has examined several periods of historical transition and corporate transformation in the United States (Prechel 2000). The most recent transformation occurred at the end of the 20th century when corporations changed their structures from the multidivisional form to the multilayer-subsidiary form (Prechel and Boies 1998)[1]. The multilayer-subsidiary form is defined by Prechel (2000, p. 12) as:

"a corporation with a hierarchy of two or more levels of subsidiary corporations with a parent company at the top of the hierarchy operating as a management company."

Unlike divisions, subsidiaries are separate legal entities in which the parent company owns more than 50% of the stock (Prechel 1997). This corporate form permits the parent company to issue up to 50% of the stock in its subsidiaries while maintaining ownership control. Thus, the multilayer-subsidiary form enhances the equity-financing capabilities of parent companies and reduces

[1] Prechel (2000) and Boies and Prechel (2002) discuss how corporations mobilized politically during the 1980s in response to declining profits and high-interest debt. They show how the corporate political activity resulted in the Tax Reform Act of 1986 and the Revenue Act of 1987 that eliminated a New Deal tax on capital transfers from subsidiary corporations to parent companies and encouraged corporations to transform their divisions into subsidiaries.

their debt dependence on banks (Boies and Prechel 2002; Prechel and Boies 1998).

An important implication for ecostructural theory is that corporations in the multilayer-subsidiary form have opportunities and incentives to evade legal liability as they externalize pollution costs. Research has shown that corporations in liability-prone industries were among the first to change to the multilayer-subsidiary form because the legal status of subsidiaries protects parent companies from subsidiary liabilities involving bankruptcies and tort lawsuits (Prechel and Boies 1998). A separate study of the electrical power industry finds that the total number of subsidiaries is positively related to toxic emissions rates for electrical power producing corporations (Prechel forthcoming). The multilevel examination here extends this line of research by examining whether the corporate subsidiary structure explains variations in facility emissions rates.

Capital Dependence of Corporations on Investors

This dissertation also incorporates the concept of shareholder value (Krier 2005; Useem 1996). The transformation to the multilayer-subsidiary form was part of a corporate restructuring that reoriented managerial practices toward financial speculation and the maximization of shareholder value (Krier 2005). Investors who own corporations have gained power in their relationship with managers who directly control corporations (Useem 1996). The point here is that the structural transformation to the multilayer-subsidiary form that made corporations less dependent on banks as sources of debt financing also made them more dependent on large institutional investors and other wealthy shareholders who purchase their securities (Prechel 2000).

The contemporary era of investor capitalism differs fundamentally from the managerial capitalism of the middle 20th century. Institutional investors with concentrated stock ownership now have a determining voice in corporate decision making that allows them to exert greater pressure on management (Useem 1996). Corporate governance has been transformed into teams of activist owners and stock-optioned executives who together implement speculative management practices to boost shareholder interests in secondary stock markets (Krier 2005). Satisfying the interests of shareholders clearly has become a powerful incentive and a top priority for corporate management.

The institutional structure of speculative finance has caused economic problems for much of U.S. society (Krier 2005). Ecostructural research has begun to study how the corporate dependence on shareholders affects environmental pollution (Prechel 2009, forthcoming). This research finds that corporate dividend payments relate positively to rates of toxic emissions that are aggregated up from the facilities to the corporations that own the facilities. These findings suggest that the priorities of corporate managers favor increasing returns to shareholders instead of improving on ecoefficiency by investing in pollution abatement technologies (Prechel 2009, forthcoming). The dissertation here draws from this line of research to examine how the corporate dependence on shareholders affects pollution at the facilities.

Energy Industry Deregulation: Expanded Opportunity for Corporations to Pollute

Energy deregulation and electrical utility restructuring have received much assessment by members of the press in recent years (Adams 2005; Dennis 2006; Kosseff 2005; Perine 2002). Historical analysis of the industry shows that corporate power producers responded to capital constraints during the 1970s and 1980s by mobilizing politically for deregulatory energy policies and by using corporate structures that are difficult to monitor and regulate (Prechel 2009; forthcoming). For example, the Energy Policy Act of 1992 established a new class of electrical wholesale generators (EWGs) that were exempt from the Public Utility Holding Company Act of 1935 and not subject to the size and fuel limitations that applied to small independent power producers under the Public Utilities Regulatory Policies Act of 1978 (Energy Information Administration 1993, 2000). These EWGs could be owned anywhere in the United States by both U.S. SEC registered and exempt utility holding companies (Energy Information Administration 1993, 2000)[2].

The critics have focused on many aspects of energy deregulation (Groth 1985; Grunwald and Eilperin 2005; Sze 2005; Timney 2002). For instance, deregulation created disincentives for investments in reliability and efficiency that could have lowered electricity rates for customers (Slocum 2008). The Energy Policy Act of 1992 is important because this act, in conjunction with the multilayer-subsidiary form, provided an early opportunity for corporations in the electrical power industry to expand their ownership of polluting power plants geographically through their subsidiaries without oversight by the U.S. SEC (Prechel 2009, forthcoming)[3]. The point here for ecostructural theory is that the deregulation and lax enforcement of the contemporary era have created opportunities and incentives for managers of power producing corporations to externalize pollution costs rather than improve on ecoefficiency (Prechel 2009, forthcoming).

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[2] In accordance with the Public Utilities Holding Company Act of 1935 (Able 1999; Energy Information Administration 1993), the U.S. SEC regulated mergers and diversification proposals by interstate public utility holding companies with subsidiaries engaging in retail electricity or natural gas distribution. The U.S. SEC also regulated the selling and purchasing of securities. Utility holding companies operating within one state or a contiguous state could qualify for exemptions from regulation by the U.S. SEC under the Public Utilities Holding Company Act of 1935.

[3] The study period for the analysis in this dissertation is the year 2004 when President George W. Bush and the U.S. Congress were in process of enacting the Energy Policy Act of 2005 that completely repealed the Public Utility Holding Company Act of 1935 and formally ended regulation of utility parent companies by the U.S. SEC (Congressional Research Service 2006).

Although the Clean Air Act Amendments of 1970 and 1990 address several pollutants such as sulfur dioxide (SO_2) that are emitted by power plants, electrical power generation remains one of the worst sources of air pollution in the United States (Black Leadership Forum 2002; National Resources Defense Council 2006; Schneider 2001). Campaign financing and the larger system of business-government relations have allowed corporate polluters to limit and delay the effectiveness of the Clean Air Act by creating loopholes, gutting regulations, and undermining enforcement (Clawson, Neustadtl, and Scott 1992). Also, environmentalists and public health advocates criticize the New Source Review exemptions that allow power producers to avoid pollution abatement upgrades at their oldest power plants. These facilities typically are the worst polluters and the most likely to burden racial-ethnic minorities and other disadvantaged communities (Gauna, O'Neill, and Rechtschaffer 2005; Levy and Spengler 2001; Levy, Greco, and Spengler 2002).

Community-Level Analysis: Environmental Justice and Local Resistance to Pollution

Environmental Justice and Theories of Environmental Inequality

An environmental justice movement arose across the United States over the course of recent decades (Bullard 1994, 2001; Faber 1998, 2008; Schlosberg

2002; Taylor 2000). The movement seeks to remedy environmental inequality and especially environmental racism. Bullard (1996, p. 497) defines environmental racism as: “any policy, practice or directive that differentially affects or disadvantages (whether intended or unintended) individuals, groups, or communities based on race or color.” Environmental justice advocates argue that environmental racism protects and enhances the quality lifestyles enjoyed by affluent Whites and causes the disparities suffered by people of color (Bryant 1995; Bullard 1993a; Getches and Pellow 2002; Grossman 1994; Lee 1992; Mohai and Bryant 1992).

Landmark studies on environmental inequality by the U.S. GAO (1983) and the Commission for Racial Justice (1987) identify racial disparities involving geographic distributions of hazardous waste facilities. Environmental justice advocates since have emphasized that their concerns involve much more than waste facilities (Bullard 1996). Research on environmental inequality has addressed many other types and sources of pollution (Black Leadership Forum 2002; Bryant and Mohai 1992; Bullard 1994; Gould, Schnaiberg, and Weinberg 1996; Stretesky and Lynch 1999). This line of research suggests that environmental inequalities born by racial-ethnic minorities and other disadvantaged populations can result from multiple causal factors and can assume many different forms.

The literature discusses various theories that address different forms of environmental inequality (Bruelle and Pellow 2006; Liu 2001; Mohai and Saha 1994, Pellow 2000; Pellow, Weinberg, and Schnaiberg 2001; Saha and Mohai 1997). Saha and Mohai (2005) concisely summarize the leading theories in terms of three basic models: the racial discrimination model, the path of least resistance model, and the rational choice model. These theoretical models are not necessarily mutually exclusive and can be complementary in situations where each provides a partial explanation for environmental inequalities (Saha and Mohai 2005). Nonetheless, the underlying themes and the central concepts differ substantially.

Proponents of the racial discrimination model have alleged that decision makers in industry and government target minority communities with pollution. They have based their argument on the long history of racial discrimination in the United States (Bullard 1993b; Bullard and Johnson 1997; Bullard, Johnson, and Torres 2000; Lerner 2005; Pulido 2000). Early attention on racial injustices involving pollution focused within the southeastern United States (Bullard 1983; Geiser and Waneck 1983; U.S. GAO 1983). Environmental justice advocates coined the term environmental racism in response to these studies and the classic study by the Commission for Racial Justice (1987) that identified racial composition as the most important factor explaining the presence of hazardous waste facilities in communities across the nation. Research then showed that minorities are disproportionately burdened by many different hazards throughout the country (Bryant and Mohai 1992; Bullard 1993b, 1994; Goldman 1993). The central claim that emerged from the early literature is that communities of color suffer more from pollution than do White communities. Environmental justice advocates have continued to advance this argument in the 21st century (Bullard 2001, 2005; Bullard et al. 2007; Checker 2005; Pulido 2000; Ringquist 2005)[4].

Even the leading proponents of the racism argument acknowledge that environmental inequalities can involve more than just race (Bullard 1996). The sociopolitical model, which is supported by Saha and Mohai (2005), suggests that minority communities and other distressed communities (i.e., poor White communities) bear the brunt of pollution because they lack the ability to resist. Low-income communities in general have little social capital and political power compared to affluent White communities (Bullard 1990; Mohai and Bryant 1992). These vulnerable communities have few resources and present a path of least resistance to decision makers in industry and government (Sahai and Mohai 2005). There is much evidence supporting this argument that shows distressed communities, some composed of Whites, bear the burdens of pollution and degradation unequally (Cable 1993; Fox 1999; Szasz 2003). For example, Gibbs (2002) reviews evidence from documents (Cerrell Associates 1984; Farren

[4] Leading environmental justice advocate Robert D. Bullard is the Director of the Environmental Justice Resource Center at Clark Atlanta University. The center provides much information with in-depth historical evaluation of the environmental justice movement. It has an extensive catalogue of evidence that supports the environmental racism argument. This information can be accessed on-line at: http://www.ejrc.cau.edu/

1992) that demonstrates clearly how decision-makers base their choices of where to site hazardous facilities specifically on the demography of the poor and powerless communities that are least likely to resist.

Lastly, the rational choice model of environmental decision making offers an alternative explanation for inequalities involving the siting and location of hazardous facilities (Been 1993; Liu 2001; Saha and Mohai 2005). The model places emphasis on legally legitimate market rationality involving the ecological competition for land use (Been 1994; Daniels and Friedman 1999; Mohai and Saha 1994; Portney 1991). Accordingly, hazardous facilities are located in low-cost areas where poor and minority populations tend to live because such areas provide the most efficient locations for rational decision makers in the siting process. Communities in areas with low land costs therefore can attract hazardous facilities and poor minorities simultaneously, and further declines in local property values after the facilities are established can attract more poor and minority people to the communities (Been 1993, 1994; Been and Gupta 1997; Rogers 1995).

Saha and Mohai (2005) focus primarily on summarizing how these models explain the siting of new hazardous facilities. This dissertation assesses how well they explain variations in pollution emitted by existing facilities. The community hypotheses elaborated in Chapter II include demographic indicators of race, poverty, and property values to test the relative merits of the models in this regard.

The Limits of Civil Rights Remedies and the Persistence of Environmental Inequality

Environmental justice received considerable attention from policy scholars during the 1990s (Foreman 1998). President George H.W. Bush first acknowledged environmental inequality as it relates to the Fourteenth Amendment in terms of equal protection and equal application of laws and regulations. An Office of Environmental Equity was established in the U.S. EPA under his administration. President Clinton then signed Executive Order 12898 (1994) that instructed all federal agencies to develop strategies for identifying and addressing environmental inequalities that adversely affect minority and low-income populations. The accompanying federal memorandum encouraged using Title VI of the Civil Rights Act of 1964 and the disparate impact standard of legality to remedy environmental inequalities that adversely affect racial-ethnic minorities (Clinton 1994). The theoretical and legal implications are important potentially (Bryner 2002; Bullard 2005; Cole 2002; U.S. EPA 1998).

Title VI and the disparate impact standard strengthen the legal strategies of environmental justice advocates – at least potentially – by blurring the causal differences that distinguish the contending theories of environmental inequality. Regardless of the different causal explanations, minority plaintiffs in environmental justice cases would have to show only that they suffer an adverse disparity for the legal burden of proof to shift onto the defendant to justify the decision that led to the disparity and show that there was no less discriminatory alternative (Bryner 2002; Cole 2002). Environmental justice advocates have focused much attention on the disparate impact standard because minority plaintiffs would no longer have to meet the difficult legal burden of proving discriminatory intent on the part of the defendant in environmental justice cases (Bryner 2002; Cole 2002).

These civil rights strategies apply potentially for disparities involving either the siting of new hazardous facilities or the abatement of pollution at existing facilities (Lee 1997). In actual practice, however, attempts to use Title VI and the disparate impact standard to remedy such disparities by suing in federal court or filing administrative actions with the U.S. EPA have been unsuccessful (Benford 2005; Gauna et al. 2005; Gordon and Harley 2005; Harden 2002). Moreover, leading environmental justice advocates have found that some of the most widely referenced environmental disparities that these strategies were expected to remedy have persisted over time and perhaps gotten worse (Bullard et al. 2007; Goldman and Fitton 1994).

Local Organizing Capacity as a Deterrent to Environmental Pollution

Saha and Mohai (2005) suggest that disparities persist because of local-based environmental organizing by affluent Whites since the 1970s. Accordingly, minority communities had limited ability to resist unwanted facilities in the 1970s, 1980s, and even 1990s because local environmental organizing by people of color developed relatively late. Other scholars suggest further that environmental justice advocates must focus more attention on organizing minority communities and working with environmental organizations to assist communities that do not share in the promise of equal environmental quality (Gordon and Harley 2005). These insights indicate that it is important to examine variations in local organizing capacity as an explanatory factor in studies that address environmental inequality.

Many scholars in the broader environmental sociology and social movement literature also have recognized the relevance of local-based organizations (Almeida 1994; Brulle 1996; Edwards 1995; Freudenberg and Steinsapir 1992). For example, Cable and Benson (1993) draw attention to local organizations in their critical evaluation of corporate crimes, polluting facilities, and the state. Accordingly, an informal control system of local organizations has emerged because the state struggles to protect citizens from local polluters. These insights are relevant here because they suggest that the government is limited in its capacity to regulate powerful corporate polluters and that non-profit organizations play a potentially important role in deterring pollution at the local-community level. Different scholars who subscribe to basic tenets of the sociopolitical model tend to agree (Fox 1999; Gibbs 2002; Kebede 2005; Pellow 2000, 2001).

Finally, the emphasis on local-based organizations brings the discussion back to ecostructural theory. Drawing from the literature on social capital and local civic engagement (Tolbert, Lyson, and Irwin 1998), ecostructural theorists suggest that scholars studying the effects of organizations on the environment must consider more than just the structural characteristics of the polluters (Grant et al. 2004). Accordingly, communities have organizational structures that can cultivate local problem solving capacities and thereby influence the behavior of the polluters. Although Grant et al. (2004) find no direct relationship between environmental pollution and community organization, they find significant interaction effects involving several indicators of local organizational capacity (i.e., the number of associations, number of churches, and number of third places[5]). The important point here is that ecostructural theorists as well as environmental justice scholars have recognized the potential deterrent effects that local organizations can have on pollution.

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[5] Third places are places separated from the home and the workplace that facilitate community solidarity and civic engagement. Grant et al. (2004, p. 194) mention the “barber shops, cafes, and other sites of informal public life” when discussing third places.

Environmental Inequality Involving Air Pollution and the Electrical Power Industry

Environmental justice advocates have long argued that racial-ethnic minorities, and poor Whites, are disproportionately vulnerable to health risks from air pollution because of disproportionate exposure (Bullard 1994; Creech and Brown 2000; Ferris 1994; Jarrell and Ozymy 2010; Lopez 2002; Maantay 2007; Pastor, Morello-Frosch, and Sadd 2005). They also have focused on electrical power generation as a major source of air pollution (Black Leadership Forum 2002; Sze 2005). However, environmental justice advocates have not conducted a national study that examines power plant emissions rates in relation to either the characteristics of corporations that own power plants or the characteristics of communities where power plants are located. This dissertation addresses these gaps in the literature by examining the effects of both corporate and community characteristics on rates of air pollution emitted by power plants located across the United States.

A classic national study by Wernette and Nieves (1992) at Argonne National Laboratory focused on air pollution by examining all counties and independent cities designated as non-attainment areas under the National Ambient Air Quality Standards (NAAQS) that are established by the U.S. EPA in accordance with the Clean Air Act[6]. The findings showed that the percentages of the Black and Hispanic populations living in the NAAQS non-attainment areas were greater than the percentage of the non-Hispanic White population living in the non-attainment areas and also greater than the percentage of the whole population (from all racial-ethnic groups) with income below poverty living in the non-attainment areas. These findings indicate that minorities are exposed disproportionately to air pollution and that their disproportionate exposure cannot be reduced simply to factors of poverty and income (Wernette and Nieves 1992).

Environmental justice advocates and other researchers since have conducted many studies that examine various forms of air pollution[7]. Some studies focus nationwide (Brooks and Sethi 1997; Daniels and Friedman 1999; Grant et al. 2002; Grant et al. 2010; Perlin, Setzer, Creason, and Sexton 1995), and others focus within different regions (Downey 1998; Grineski, Bolin, and Boone 2007; Kriesel and Centner 1996; Pastor et al. 2005; Touché and Rogers 2005). Some of these studies examine cumulative distributions of air pollution from multiple sources (Daniels and Friedman 1999; Downey 1998; Pastor et al. 2005), and

[6] The U.S. EPA has established NAAQS for several criteria pollutants under the Clean Air Act. Specified criteria pollutants include sulfur dioxide, nitrogen dioxide, particulate matter, ground-level ozone, carbon monoxide, and lead. The U.S. EPA also is responsible for identifying areas that have excess levels of these criteria pollutants. These areas are referred to as NAAQS non-attainment areas. Further information on NAAQS is available on the website of the U.S. EPA at: http://www.epa.gov/air/criteria.html

[7] The total body of research examining ambient air pollution in relation to demographic characteristics includes many studies that focus on Clean Air Act criteria pollutants and many different studies that focus on other pollutants included in the U.S. EPA Toxics Release Inventory.

others examine rates of air pollution emitted by specific types of facilities (Grant et al. 2002; Grant et al. 2010; Touché and Rogers 2005).

The results and findings of these and other air-pollution studies are mixed. The early ecostructural studies do not find demographic inequalities involving facility emissions rates in the chemical industry (Grant et al. 2002; Grant and Jones 2003). However, much research indicates that there are inequalities involving various forms of air pollution and the demographic characteristics examined in this dissertation.

Many studies find that air pollution is significantly related to race, poverty, and sometimes both these factors (Brooks and Sethi 1997; Daniels and Friedman 1999; Maantay 2007; McCaull 1976; Pastor et al. 2005). Many studies also find that air pollution is significantly related to property values (Brooks and Sethi 1997; Daniels and Friedman 1999; Jerrett, Burnett, Kanaroglou, Eyles, Finkelstein, Giovis, and Brook 2001; Touché and Rogers 2005). Some of these studies suggest that quadratic terms should be included when explaining air pollution inequalities (Brooks and Sethi 1997; Daniels and Friedman 1999; Pastor et al. 2005). Accordingly, poverty and income variables have curvilinear relationships with air pollution. The analysis in this dissertation thus includes a squared term for poverty to test for a quadratic relationship and identify the threshold value at which the effect of poverty on power plant emissions rates becomes positive. The point taken from this broad literature is that the demographic characteristics examined in this dissertation relate significantly to air pollution in general.

A national report by the Black Leadership Forum (2002) focuses specifically on power plants as principal emitters of air pollution. The report finds that a greater percentage of Blacks compared to Whites live within 30 miles of a power plant. It also stresses that the maximum effects of the pollution occur within this distance (Black Leadership Forum 2002). Indeed, research at the Harvard School of Public Health indicates that air concentrations of SO_2 and primary particulate matter are greatest within five miles of power plants (Levy and Spengler 2000). This research indicates further that per capita health risks of these pollutants are greatest near power plants and decrease with distance from power plants (Levy and Spengler 2000). Associated research at the Clean Air Task Force also recognizes that communities in close proximities to power plants are directly affected by air pollutants (i.e., SO_2) emitted by power plants (Hill and Baum 2001).

There are two problems with the national report by the Black Leadership Forum (2002). First, the report is limited because it merely points out that a relatively large percentage of the Black population – a small population compared to the White population – lives in geographic areas around power plants. It does not examine air pollution emitted by power plants in relation to demographic characteristics of areas around power plants. In other words, it does not address the question of whether power plants located in geographic areas where Blacks are concentrated emit air pollution at higher rates than power plants located in areas inhabited mostly by Whites.

The second and more fundamental problem is that the Black Leadership Forum (2002) does not observe the specific communities where the power plants are located. This is an important point that involves sources of pollution other than just power plants. The basic problem follows in accordance with the geo-unit debates that received prominent attention in the literature after Anderton, Anderson, Rossi, Oakes, Fraser, Weber, and Calabrese (1994) showed that a relatively minor geo-unit size change from zip codes to census tracts results in different demographic findings when examining communities where waste facilities are located. The much larger areas (i.e., 60 miles in diameter) examined by the Black Leadership Forum (2002) are subject to criticisms of ecological fallacies involving population aggregations, which have long been recognized as problematic by sociologists and demographers (Anderton et al. 1994; Robinson 1950).

A widely referenced report by the Institute of Medicine (1999) at the National Academies addresses the basic problem by recommending that researchers examine the specific communities where specific hazards of interest are located and characterize the nature and severity of risk exposure by direct measurement or estimation. Accordingly, assertions of environmental inequalities are well founded and warrant careful assessment (Institute of Medicine 1999). This dissertation moves beyond the limits and problems of the Black Leadership Forum (2002) in these regards. Although this national study does not directly observe risk exposures and health effects, it does examine the demographic characteristics of the specific communities where the power plants are located in relation to rates of air pollution emitted by the power plants.

A previous study by Touché and Rogers (2005) examines 28 communities in Texas that were sited with coal and gas power plants between 1970 and 1990. The study is relevant because Texas is an energy-producing state that has a high aggregate level of air pollution from electrical power generation and a large population of minorities. Nonetheless, the study finds no disparities adversely affecting minority communities in either its longitudinal analysis of power plant sitings or its cross-sectional analysis of power plant emissions rates (Touché and Rogers 2005). The analysis, however, does not include many older power plants that were established in earlier decades. This is important because of the New Source Review exemptions to the Clean Air Act that allow older power plants to avoid pollution abatement upgrades. Such old facilities are most likely to burden communities with a high proportion of disadvantaged citizens (Levy and Spengler 2001; Levy et al. 2002; Gauna et al. 2005). Also, cases outside of Texas suggest that post-1990 energy deregulation has caused disparities involving more recently established power plants (Sze 2005).

The examination here includes fossil-fuel plants (i.e., coal, natural gas, and oil) regardless of age that are located in many different communities across the continental United States. This multilevel research contributes to the literature in several ways. First, it moves beyond previous environmental justice research by examining characteristics of the corporations that own the facilities. Second, it examines variations in local organizing capacity as well as variations in the demography of the local communities. Third, it controls for several facility characteristics that otherwise could bias the findings. The control variables are discussed in the next chapter after the theoretical framework is summarized and the hypotheses are elaborated.

CHAPTER II

CORPORATE AND COMMUNITY HYPOTHESES

There are two sets of hypotheses. The first set addresses the first research question by examining the effects of corporate characteristics on power plant emissions rates. The second set addresses the second research question by examining the effects of local community characteristics on power plant emissions rates. The opening section of this chapter follows the previous chapter by briefly summarizing the theoretical framework from which the hypotheses are derived.

SUMMARY OF THEORETICAL FRAMEWORK

Ecostructural theory provides the conceptual basis for the corporate analysis. This theory focuses on organizations and the effects of organizational structures on environmental pollution (Grant et al. 2002). Recent developments of ecostructural theory (Prechel 2009, forthcoming; Prechel and Zheng 2009) draw from resource dependence theory (Pfeffer and Salanik 1978) and the shareholder conception of value (Krier 2005; Useem 1996).

Resource dependence theory suggests that organizations are externally constrained and controlled by inter-organizational resource dependencies and that under certain conditions they can respond actively by changing their structures and recreating their networks of interdependencies (Pfeffer and Salanik 1978). This theory also suggests that new resource dependencies can emerge when organizations cope with previous resource dependencies (Pfeffer and Salanik 1978). Previous research on capital dependence shows that the contemporary transformation in corporate form and the increased dependence of corporations on investing shareholders have created opportunities and incentives that explain financial malfeasance (Prechel 2003; Prechel and Morris 2010).

The dissertation here follows in accordance with resource dependence theory and the ecostructural theory elaborated by Prechel (2009, forthcoming) to specify how the organizational structure and financial characteristics of corporations create dependencies, opportunities, and incentives that affect ecoefficiency. This multilevel examination addresses ecoefficiency by examining power plant emissions rates. Power plants that emit less pollution and generate more electricity are more ecoefficient than power plants that emit more pollution and generate less electricity.

The examination of the local communities follows from the three theoretical models summarized by Saha and Mohai (2005). The elaboration of hypotheses addresses the racial discrimination model first because environmental justice and civil rights advocates have argued most forcefully that – whether intended or unintended – minority communities bear a disproportionate share of pollution. The local community hypotheses then address the rational choice model and the sociopolitical model, which suggests that minority and other distressed groups bear the burdens of pollution unequally because they have little capacity to resist.

SPECIFICATION OF HYPOTHESES

The following sections elaborate the corporate and the community hypotheses. The specification of characteristics used to test the corporate hypotheses precedes the specification of characteristics used to test the local community hypotheses. Several facility control variables are specified at the end of this chapter.

Corporate Characteristics

There are three corporate characteristics. The first of these hypotheses focuses on corporate size. The second and third corporate hypotheses focus on structural and financial characteristics that involve the multilayer-subsidiary form and the shareholder conception of value.

Corporate Size

Organizational size is an important characteristic in ecostructural research. After all, firm size is the only corporate characteristic included in the early study by Grant et al. (2002) that examines facility emissions rates in the chemical industry. Although they focus primarily on the relationship between facility size and facility emissions rates, the model they consider best in their analysis shows that firm size also has a significant positive effect on the rates at which chemical facilities emit toxic air pollution (Grant et al. 2002).

However, theoretical disagreement exists about the relationship between organizational size and environmental pollution. Whereas the work of some organizational theorists suggests that pollution rates would be higher in larger organizations (Mokhiber and Weissman 1999; Perrow 1997), other theorists suggest that larger organizations with more resources would have lower pollution rates (Hamilton 1995). Recent ecostructural research examining rates of toxic emissions that are aggregated up to the ultimate parent company finds that larger corporations are more ecoefficient than are smaller corporations (Prechel 2009; Prechel and Zheng 2009).

The first hypothesis in this dissertation tests the effects of corporate assets on facility emissions rates in the electrical power industry. Explaining emissions rates at the facilities is fundamentally important because, as shown later in the dissertation, much of the variation in pollution exists at the facility level. The direction of the hypothesis follows Grant et al. (2002) since they also explain pollution rates at the facility level as they demonstrate the effects of size – firm size and facility size – on facility emissions rates. The hypothesis is stated as follows:

Hypothesis 1: The total corporate assets are positively related to power plant emissions rates.

Corporate Form

Recent developments of ecostructural theory focus on meso-organizational characteristics other than corporate size (Prechel forthcoming; Prechel and Zheng 2009). Previous research in organizational and political sociology demonstrates that the multilayer-subsidiary form has been widely adopted in corporate America (Boies and Prechel 2002). This line of research also shows that this corporate form allows and encourages managers to engage in financial malfeasance (Prechel 2003; Prechel and Morris 2010).

Ecostructural theory suggests that the multilayer-subsidiary form creates dependencies, opportunities, and incentives for managers to externalize pollution costs (Prechel forthcoming). Business law treats a subsidiary as a separate entity from its parent company even if all its stock is owned by its parent company and all managers serving on its board of directors serve on the board of directors for its parent company (Allison, Prentice, and Howell 1991). This separation creates liability firewalls, which Prechel (2000, p. 54) defines as "barriers among legally independent subsidiary corporations and the parent company." Parent companies are shielded from risks in the subsidiaries because the courts rarely pierce this corporate veil. As noted by Prechel (1997, p. 497), the "corporate veil protects the parent company's assets by containing economic losses, bankruptcy, and tort liability lawsuits to the subsidiary corporation." This is important for ecostructural theory since parent companies are protected from liabilities involving polluting activities in their subsidiaries (Prechel forthcoming).

Ecostructural theory further emphasizes the overall structural complexity of the multilayer-subsidiary form (Prechel 2009; Prechel and Zheng 2009). Corporations in the multilayer-subsidiary form are structured such that lower levels of subsidiaries are embedded under higher levels of subsidiaries that finally are embedded directly under the ultimate parent company at the top of the corporate structure (Prechel 1997, 2000). Ecostructural theorists argue that this type of structural complexity makes corporations less ecoefficient (Prechel and Zheng 2009).

The second hypothesis tests the complexity argument by focusing on the total number of subsidiaries in the corporate structure. Research focusing specifically on the electrical power industry has shown that there is a positive relationship between the total number of subsidiaries in the corporate structure and corporate pollution (Prechel forthcoming). This multilevel examination expects to find that the total number of subsidiaries also has contextual effects that explain facility emissions rates. Therefore,

Hypothesis 2: The total number of subsidiaries in the corporate structure is positively related to power plant emissions rates.

Corporate Dependence on Shareholders

The shareholder conception of value (Krier 2005; Useem 1996) is a considered a resource constraint within the framework of this dissertation. Corporate ownership has become concentrated in the hands of large institutional investors who actively pressure corporate management to improve stock performance and increase returns to shareholders (Useem 1996). Executive compensation and succession have become contingently aligned with the expansion of shareholder wealth (Useem 1996). The corporate executives and the institutional investors now share opportunistic incentives and speculative interests in short-term investment trends that are not in accordance with the overall long-term good (Krier 2005).

Environmental sociologists critical of economic organizations have suggested that the volatility in contemporary patterns of investment and capital accumulation creates environmental disruptions (Schnaiberg and Gould 1994). Ecostructural theory maintains that the equity financing capabilities of corporations in the multilayer-subsidiary form have made management more dependent on the investors who purchase corporate securities (Prechel 2009, forthcoming). Accordingly, this new layer of capital dependence has created incentives and opportunities for corporate managers to externalize pollution costs. The basic argument here is that the dependence of corporations on investors allows and encourages managers to maximize shareholder returns rather than invest in pollution abatement technologies.

The third hypothesis examines the multilevel effects of corporate dividend payments on facility emissions rates. Recent ecostructural research finds that the corporate dividends paid per share relate positively to corporate pollution (Prechel 2009; forthcoming). The examination here expects to find that the corporate dividends paid per share also have a significant positive effect on facility emissions rates.

Hypothesis 3: The corporate dividends paid per share are positively related to power plant emissions rates.

Local Community Characteristics

There are four local community characteristics. The first three community hypotheses focus on demographic characteristics. Specifically, they focus on racial composition, poverty, and property values. The fourth of these hypotheses focuses on local non-profit organizations.

The elaboration of these hypotheses follows from the theoretical models summarized in the previous chapter: the racial discrimination model, sociopolitical model, and rational choice model. The elaboration here differs from Saha and Mohai (2005) in that it assesses how these models explain the unequal abatement of pollution at existing facilities instead of evaluating how they explain inequalities involving the siting of new hazardous facilities.

Minority Communities

Environmental justice advocates cite a classic study by Lavelle and Coyle (1992) as they argue that environmental inequalities involve more than just the siting of hazardous facilities (Bullard 1994, 2001; Checker 2005; Getches and Pellow

2002). The findings of Lavelle and Coyle (1992) indicate that racial disparities involving the mitigation and regulation of environmental risks at waste facilities continue long after the facilities are initially established. The findings also indicate that that the racially unequal environmental protection often occurs regardless of whether the local communities are wealthy or poor (Lavelle and Coyle 1992).

The racial discrimination model offers perhaps the best theoretical explanation for findings such as those reported by Lavelle and Coyle (1992). However, the civil rights strategies advanced by environmental justice advocates blur the causal reasoning because discriminatory intent can be very difficult to prove legally (Bryner 2002; Bullard 2001; Cole 2002). Bullard’s (1996, p. 497) words “whether intended or unintended” in his definition of environmental racism follow in accordance with the Clinton (1994) federal memorandum on Title VI and the attempts by environmental justice advocates – though not yet successful – to apply the disparate impact standard in cases where the environmental disparities adversely affect racial-ethnic minorities (Bryner 2002; Cole 2002; Lee 1997).

Environmental justice advocates argue that minorities suffer disproportionately from air pollution in general (Bullard 1994; Creech and Brown 2000; Lopez 2002; Maantay 2007; Pastor et al. 2005; Wernette and Nieves 1992). The national report *Air of Injustice* by the Black Leadership Forum (2002) points out that a relatively large percentage of Blacks live in areas around power plants where maximum effects of the emissions typically occur. Although the study by Touché and Rogers (2005) finds no adverse racial-ethnic disparities involving power plant emissions rates in Texas, the analysis only includes power plants that were established between 1970 and 1990. Environmental justice advocates and other researchers indicate that the New Source Review exemptions to the Clean Air Act and the post-1990 energy deregulation have created inequalities involving both older and newer facilities (Levy and Spengler 2001; Levy et al. 2002; Gauna et al. 2005; Sze 2005). Following the Black Leadership Forum (2002), the fourth hypothesis is stated as follows:

Hypothesis 4: The percentage of the community that is Black is positively related to power plant emissions rates.

Poor Communities

Environmental justice advocates acknowledge that poor populations other than racial-ethnic minorities (i.e., poor Whites) can experience environmental inequality (Bullard 1996; Saha and Mohai 2005). After all, low-income populations are included with minority populations in President Clinton's Executive Order 12898 (1994). From the iconic case of toxic waste pollution at

Love Canal (Gibbs 2002; Szasz 2003) to the poverty and degradation in Appalachia (Cable 1993; Fisher 1993; Fox 1999), the literature recognizes that the environmental inequities experienced by economically disadvantaged White communities need to be addressed.

The sociopolitical model summarized by Saha and Mohai (2005) logically explains the environmental inequities born by poor people. The path of least resistance theory underpinning the model posits that low-income populations, poor Whites and poor minorities, have little influence on environmental decision making because they lack social capital and political power in general and are underrepresented throughout industry and government (Gibbs 2002; Mohai and Bryant 1992). Compared to affluent Whites, poor people simply have less capacity to oppose those responsible for polluting their communities.

Environmental justice advocates include low-income populations among the disadvantaged groups that suffer because of power plants and other sources of air pollution (Gauna et al. 2005; Jerrett et al. 2001; McCaull 1976; Sze 2005). This dissertation accepts the theoretical underpinnings of the sociopolitical model and logically presumes that poor communities present a path of least resistance to managers responsible for abating emissions and regulators responsible for enforcing compliance with emissions laws. The fifth hypothesis is stated in standard linear form. However, one model in the analysis includes a squared term for poverty because researchers suggest that poverty and income variables have quadratic relationships with air pollution (Brooks and Sethi 1997; Daniels and Friedman 1999; Pastor et al. 2005). The linear form of the hypothesized relationship is expressed as follows:

Hypothesis 5: The percentage of the community that is living in poverty is positively related to power plant emissions rates.

Community Property Values

The rational choice model embraces the theme of legal-legitimate market rationality (Been 1993, 1994; Liu 2001; Portney 1991; Saha and Mohai 2005). The model presumes that communities with low land costs simultaneously attract industrial decision makers as they select where to site facilities and poor minorities as they decide where to reside. The model also addresses post-siting demographic changes by recognizing that downward pressures on property values after the facilities are established can discourage rich whites from living in these communities and encourage poor and minority people to live in these communities (Been and Gupta 1997; Rogers 1995; Saha and Mohai 2005).

Such arguments are dubious when it comes to justifying the unequal abatement of pollution after the facilities are established because the legal legitimacy assumption underpinning the model no longer stands. Logically, the model could be extended by recognizing that communities with the worst polluting facilities would have the lowest property values and thus would attract the most low-income minorities. As stressed by environmental justice advocates, however, laws involving the mitigation and regulation of pollution at hazardous facilities are supposed to apply equally regardless of the demographic characteristics of the communities where facilities are located (Bullard 1994; Bullard and Johnson 2000; Bullard et al. 2007; Cutter 1995; Ferris 1994; Lavelle and Coyle 1992).

This point is emphasized by Touché and Rogers (2005) as they discuss their findings that indicate local home values in Texas relate negatively to power plant emissions rates. Although managers in the power industry have a legal right to site new facilities in communities with low property values, they have no legal right to violate emission laws at existing facilities that are located in communities with low property values. Even if proponents of the rational choice model were to argue that it is rational to break laws, such arguments would be contingent on socio-political factors to explain why managers break laws at some facilities but not at other facilities. All else equal, violating emissions laws at facilities located in communities with low property values does not reduce pollution abatement costs any more than violating emissions laws at facilities located in communities with high property values. The difference is sociopolitical in that low property value communities have less capacity to exert pressure on the managers responsible for violating emissions laws and the regulators responsible for enforcing compliance with emissions laws. In other words, disregard for emissions laws follows the path of least resistance.

This is a sociopolitical explanation more than a rational choice explanation because resistance involves the basic concept of power. As argued by many organizational and political sociologists, power is conditional and exists in social relationships involving more than the standard rational choice factors that center on individual calculations of cost efficiency and economic utility (Emerson 1962; Pfeffer and Salancik 1978; Roy 1997). In accord with the sociopolitical model of environmental inequality (Sahai and Mohai 2005), the hypothesis is stated as:

Hypothesis 6: The community property values are negatively related to power plant emissions rates.

Local Organizing Capacity

Local organizing capacity is vital in the sociopolitical model because local areas with little organizing capacity present a clear path of least resistance. This basic reasoning is substantiated by Saha and Mohai (2005) as they discuss the late development of environmental organizing by people of color and the persistence of disparities involving hazardous facilities. Research on the traditional civil rights movement has long recognized that indigenous organizational strength is a key component in the political process (McAdam 1982). It is important for the viability of the contemporary environmental justice movement that minorities strengthen their organizing capacity and work through environmental organizations to oppose those responsible for polluting their communities (Gordon and Harley 2005; Saha and Mohai 2005).

Many environmental sociologists and social movement scholars have recognized the deterrent effects that local-based organizations can have on pollution (Brulle 1996; Cable and Cable 1995; Edwards 1995; Freudenberg and Steinsapir 1992; Kebede 2005; Pellow 2001). Regardless of community demography (e.g., Black or poor White), these scholars indicate that local organizations can make a difference. Their insights suggest that areas with relatively few local organizations present a path of least resistance in the sociopolitical model.

The classic work of Cable and Benson (1993) that addresses corporate crimes involving polluting facilities draws specific attention to local environmental organizations. Other scholars indicate that different types of local non-profit organizations (e.g., health organizations and community development organizations) also can affect environmental pollution and degradation (Almeida 1994; Brown, Mayer, Zavestoski, Luebke, Mandelbaum, and McCormick 2005;

Fischer 1993; Freudenberg and Steinsapir 1992). Accordingly, local organizations of various kinds serve as headquarters for social movements and provide communities with networking opportunities to enhance their social capital and strengthen their organizational capacity so that they can effectively address social and environmental problems.

This examination focuses on the total number of non-profit organizations in the county as an indicator of local organizing capacity. The ecostructural study by Grant et al. (2004) also focuses at the county level when drawing from the literature on social capital and civic engagement (Tolbert et al. 1998) to study the effects of associations, churches, and third places on chemical plant emissions rates. The argument here is that communities in counties with relatively few non-profit organizations have less capacity to pressure managers and regulators to abate pollution.

Hypothesis 7: The total number of non-profit organizations in the county is negatively related to power plant emissions rates.

CONTROL VARIABLES

The research questions stated in Chapter I focus on corporate characteristics and local community characteristics. Nevertheless, this examination also includes several power plant characteristics as control variables. Failure to account for the potential effects of these facility characteristics on facility emissions rates could bias the testing of the corporate and community hypotheses.

Facility size is included in the examination because the ecostructural study by Grant et al. (2002) shows that large facilities pollute at higher rates than do small facilities. Facility age is included as another control variable because the New Source Review exemptions to the Clean Air Act allow old facilities to avoid pollution abatement upgrades. Also, structural inertia arguments in sociology indicate that age, as well as size, can impede change (Hannan and Freeman 1984). The basic argument is relevant here because it suggests that pollution abatement upgrades are more difficult to implement at older and larger facilities than at newer and smaller facilities.

In addition, the examination here includes a facility variable to control for the percentage of the total electricity generated that is produced from coal. After all, environmental scientists generally recognize coal as the fossil fuel most responsible for power plant emissions. A dummy variable also is included to identify cogeneration facilities that produce a combination of electricity and useful heat energy. Environmental scientists recognize this type of facility for being energy efficient and environmentally friendly. Chapter III provides further discussion of these variables and their measures.

Finally, this examination includes one local demographic control variable. Population density is an important variable in functionalist sociology and human ecology. Research on air pollution and environmental inequality has included population density as a land-use control variable (Brooks and Sethi 1997; Pastor et al. 2005). Accordingly, the clustering of industry, housing, transportation, and other land-use activities in high-density areas can affect how local demographic characteristics such as race, income, and property values relate to environmental pollution.

CHAPTER III

RESEARCH DESIGN

This dissertation applies a multilevel research design to examine the main effects of the corporate characteristics and community characteristics on facility emissions rates. The examination focuses on electrical generating power plants located across the continental United States. This is a cross-sectional design in that emissions rates are observed for one year. Also, the analysis concentrates on one specific pollutant of interest – SO_2. In all, the multilevel models shown in the next chapter explain the main effects of the corporate characteristics and community characteristics on rates of SO_2 emitted by power plants in the United States for the year 2004.

The power plants examined in this multilevel analysis are owned by the largest electrical power-producing corporations in the United States. These corporations (i.e., ultimate parent companies) are defined as those with 49 as their primary two-digit SIC code, as identified by Compustat. This two-digit SIC code includes electric, gas, and sanitary services[8]. Closer inspection of three-digit and four-digit SIC codes indicates that the corporations in this analysis have their primary

[8] No corporation with a 49 primary two-digit SIC code in this analysis has a 495 three-digit SIC code classification for sanitary services. Although some large and profitable corporations with primary lines of business in sanitary services own facilities that generate electricity, no sanitary service corporation generates enough electricity at its facilities to be included by the data source as one of the largest power-producers in the United States (National Resource Defense Council 2006).

lines of business concentrated in electric and gas services[9]. These large energy-producing corporations dominate much of the electrical power industry[10]. This industry is widely recognized as one of the most economically important and environmentally polluting industries in the United States (Bent, Orr, and Baker 2002; Fox-Penner 1997; Sze 2005).

THE STUDY GROUP

The study group comes from a larger study population defined by the National Resource Defense Council (NRDC) that includes all power plant facilities owned by the 100 largest power producers in the United States. These power plants are responsible for almost 90 percent of all electricity generation and air emissions in the electrical power industry (NRDC 2006)[11]. The NRDC has compiled separate biannual data sets that account for mergers, acquisitions, and changes in facility ownership over two year periods to identify the power plants owned by

[9] The primary three-digit SIC codes of the corporations in this multilevel analysis include 491 (electrical services), 492 (gas production and distribution), 493 (combined utility services), and 499 (cogeneration). Further inspection of secondary three-digit SIC codes indicates that most of the corporations have business activities in more than one of these sub-classification areas.

[10] This dissertation recognizes that energy-producing corporations with different three-digit SIC codes might tend to use different fossil fuels to generate electricity at their power plants. As the multi-level analysis explains emissions rates at the facility level, variables are included at the facility level to control for variations in the fuel mix across facilities and for whether or not a facility engages in cogeneration.

[11] The NRDC 2006 biannual report discusses in detail the methodological and technical specifics of how the NRDC benchmarks the air emissions of the 100 largest power producers for base year 2004 (NRDC 2006). The NRDC has similar 2004 and 2008 biannual benchmarking reports that correspond to the NRDC data sets for base years 2002 and 2006, respectively.

the 100 largest power producers. At the time of this analysis[12], the NRDC website had made publicly available separate biannual data sets that benchmark the air emissions of the top 100 power producers for base years 2002, 2004, and 2006. The dissertation uses the 2004 data set[13].

Only fossil-fuel power plants are included in the study group because there are no SO_2 emissions from electricity generated using other major energy sources such as hydrological power and nuclear power. Electrical generating facilities that are owned by top 100 power producers but do not generate 100 percent of their electricity from fossil fuels (i.e., coal, natural gas, and oil) thus are excluded. The study group also excludes any facility not recorded for the year 2004 in the Acid Rain Program facility unit database at the Clean Air Markets – Data and Maps section of the U.S. EPA website[14]. The NRDC indicates that emissions information reported in the Acid Rain database account for nearly all of the SO_2 emissions by the 100 largest power producers in 2004 (NRDC 2006)[15]. The NRDC stresses that the emissions information in this database is

[12] The NRDC since has made publicly available a 2010 biannual report with a corresponding data set benchmarking the air emissions of the 100 largest power producers for base year 2008.

[13] The 2004 data set is used because 2004 is closer than 2006 to the 2000 Census and because the 2004 data improve on general methodological and technical issues involving the 2002 data.

[14] For instance, fossil-fuel power plants ultimately owned by the top 100 power producer Hawaiian Electric Industries that otherwise would be included in the study group are excluded because facilities in Hawaii are not reported in the Acid Rain Program facility unit database at the Clean Air Markets – Data and Maps section of the U.S. EPA website.

[15] The NRDC (2006) indicates that, in total, approximately 2 percent of SO_2 emissions assigned to the top 100 power producers are not reported in the U.S. EPA Acid Rain database. Hence, the

collected from continuous emissions monitoring systems, which are recognized as providing the most reliable emissions information (NRDC 2006).

The study group does include cogeneration facilities that produce a combination of electricity and steam or some other useful form of energy. The NRDC adjusts the emissions data for such facilities to estimate only the emissions associated with electricity generation (NRDC 2006). The NRDC adjustments make the rates of SO_2 emitted by such facilities comparable to the rates emitted by the other facilities in the study group. Nevertheless, the models in the analysis include a dummy variable indicating whether a power plant is a cogeneration facility.

As the examination includes only large and publicly traded domestic corporations, the study group excludes all power plants owned by governmental and other types of organizations that do not have data on corporate-level variables tested in the analysis. All facilities owned by foreign corporations and corporations with primary two-digit SIC codes other than 49 (e.g., Goldman Sachs) are excluded because such corporations are categorically different from the energy-producing corporations in the analysis. These other types of corporations accumulate most of their capital in different lines of business and

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NRDC had to collect emissions data for a relatively few facilities from state agencies. This analysis excludes such facilities because of questionable reliability standards involving the emissions data and because of the methodological problem of identifying the longitude and latitude coordinates used to specify the zip codes and census tracts in which the facilities are located.

are potentially subject to different regulations and capital constraints that can affect their organizational structures and their financial statements[16].

Finally, the study group excludes any power plant that is partly owned by more than one ultimate power producer organization. The NRDC data set lists each such power plant multiple times and weights its electricity and emissions data according to the proportion of ownership held by each power producer that owns any part of the facility. None of these facilities can be assigned to any one corporation in the multilevel analysis[17]. Moreover, some of the parent companies with partial ownership in such power plants are types of organizations that are excluded from the analysis based on the criteria mentioned in the above paragraph.

In all, the study group consists of 536 power plants. These facilities are owned by 51 corporate power producers. Each of these corporations owns, on average, about 11 of the power plants.

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[16] Goldman Sachs, for instance, owns facilities that generate enough electricity for the corporation to be included among the largest power producers in the United States (NRDC 2006). Nonetheless, Goldman Sachs has its primary lines of business concentrated in banking and financial services. This corporation, unlike the corporations included in the multilevel analysis, is subject to government regulations involving commercial and investment banking that can affect its organizational structure and its financial statements.

[17] The study group does include any power plant listed by the NRDC multiple times in accordance with different facility sub-unit divisions that are owned by the same corporation. For each such facility, the analysis aggregates all of the generation and emissions data from the different sub-units and then assigns the facility to the one corporation that owns 100 percent of the combined facility.

This dissertation defines the study group using the NRDC database instead of two other widely used sources. One is the U.S. EPA's Toxics Release Inventory, which does not include data on SO_2 emissions. The next section discusses the relevance of this pollutant to the electrical power industry and the regulation of facilities in this industry under the Clean Air Act. The other data source is the U.S. EPA's Emissions and Generation Resource Integrated Database (EGRID), which is systematically inaccurate in how it identifies the corporations that own the power plant facilities. For example, EGRID uses the 2006 ownership structure to identify the facility owners in 2004. Ownership changes between 2004 and 2006 thus result in EGRID assigning the wrong corporate owners to the power plants in 2004. The NRDC database corrects this problem as it combines 2004 facility emissions data from the Acid Rain Program in the U.S. EPA with 2004 facility generation data from the Energy Information Administration (EIA) in the U.S. Department of Energy and then accounts for ownership changes so that the 2004 ownership structure accurately identifies the owners of the facilities.

VARIABLE MEASURES AND DATA

Table 3.1 summarizes the variables, measures, and data used in this analysis. The dependent variable is summarized first. The corporate predictor variables and community predictor variables than are summarized. Lastly, the facility control variables and the local demographic control variable are summarized.

Table 3.1. Variable Measures and Data Sources

Variable	Measurement Description	Source
Dependent Outcome Variable		
Facility SO_2 Emissions Rates	Log of power plant SO_2 emissions rates measured as pounds per megawatt hour.	NRDC
Level-2 Corporate Predictor Variables		
Corporate Size	Total Assets in millions of dollars (/100).	Comp
Number of Subsidiaries	Total number of subsidiaries in corporate structure.	D&B
Dividends Paid Per Share	Common dividends paid divided by number of shares.	Comp
Level-1 Local Community Predictor Variables		
Community Percent Black	Percentage of population in community where power plant located that is Black. Zip codes and census tracts examined separately.	Census
Community Percent Families in Poverty	Percentage of families in community where power plant located that is in poverty. Zip codes and census tracts examined separately.	Census
Community Median Home Value	Median home value of specified owner occupied housing units in community where power plant located (/10,000). Zip codes and census tracts examined separately.	Census
Local Non-Profit Organizations	Log of total number non-profit organizations in county where power plant located.	CCS
Level-1 Power Plant and Local Control Variables		
Facility Size	Log of power plant megawatt nameplate generating capacity.	EIA
Facility Age	Measured by subtracting from 2004 the year that the oldest active or retired generator began operating at power plant.	EIA
Facility Percent Coal Generation	Divide megawatt hours of electricity generated from coal by megawatt hours of electricity generated from all sources and then multiply by 100.	NRDC
Cogeneration Facility	Dummy variable 1 if any generating unit at power plant a co-generation unit, 0 otherwise	EIA
Local Population Density	Person per square mile in county where power plant located (/100).	Census

NRDC is National Resource Defense Council; Comp is Compustat; D&B is Dun and Bradstreet; Census is U.S. Census Bureau; CCS is Center for Charitable Statistics; EIA is Energy Information Administration in U.S. Department of Energy.

Dependent Variable

The SO_2 emission rate at the facility level is used as the dependent variable because of its importance to domestic environmental policy and the U.S. electrical power industry. For decades, the U.S. EPA has concentrated on SO_2 as a criteria pollutant in accordance with the Clean Air Act Amendments of 1970. Moreover, in accordance with Title IV of the Clean Air Act Amendments of 1990, the U.S. EPA administers the Acid Rain Program to reduce SO_2 emitted by fossil-fuel power plants nationwide[18]. The two phases of SO_2 emission reduction requirements under the program together affect power plants located across the United States that generate electricity from coal, oil, and natural gas[19]. The Phase I and Phase II requirements have been in place since the years 1995 and 2000, respectively. Yet, electrical generating facilities are responsible for about two-thirds of all SO_2 emissions in the United States (Creech and Brown 2000; Fox-Penner 1997; Munson 2005; NRDC 2006).

Many scholars have recognized the harms to human health and the natural environment caused by power plant SO_2 emissions (Fox-Penner 1997; Koenig

[18] The Clean Air Act Amendments of 1990 also created a national cap and trade system specifically to reduce SO_2 emissions. This nationwide program is considered a model for expanding cap and trading systems for nitrogen oxides and other emissions. More information on cap and trade systems involving different emissions is available from the Clean Air Markets division of the U.S. EPA.

[19] The NRDC (2006) provides a brief summary of Title VI of the Clean Air Act and the two phases of SO_2 emission reduction requirements for fossil-fuel power plants. Further information on the Clean Air Act, the Acid Rain Program, and Phase I and Phase II of the SO_2 emission reduction requirements is available from the Clean Air Markets division of U.S. EPA.

2000; Lee, 2002; Levy and Spengler 2001; Schneider 2001). The environmental and public health literature indicates that SO_2 emissions directly harm communities near power plants (Hill and Baum 2001; Levy and Spengler 2000). Accordingly, harmful effects of SO_2 on human health include bronchial reactions, reduced lung functions, respiratory diseases, cardiovascular diseases, and premature deaths. Also, the SO_2 contributes to the formation of secondary fine particulate matter – commonly referred to as sulfates – that that can cause respiratory, pulmonary, and cardiac problems for people living farther downwind from the power plants (Lee 2002; Levy and Spengler 2001; Levy et al. 2002). The sulfate compounds then mix with water in the atmosphere to form acid deposition that can travel hundreds of miles from the source. The SO_2, the sulfates, and the acid rain also harm the natural and built environments by damaging vegetation, eroding soils, impairing crops, killing aquatic life, and corroding structures and materials (Hill and Baum 2001; Lee, 2002).

In sum, focusing on SO_2 as the dependent variable in this multilevel examination is important for several reasons. First, power plants emit more SO_2 than any other source of air pollution in the United States (Creech and Brown 2000; Fox-Penner 1997; Munson 2005). Second, power plants owned by the largest power-producing organizations in the United States are together responsible for most of the SO_2 emissions in the electrical power industry (NRDC 2006). Third, the communities where power plants are located are especially vulnerable to SO_2

emissions (Hill and Baum 2001); research on environment and public health indicates that air concentrations of SO_2 and per capita mortality risks from exposure to SO_2 are greatest near power plants and decrease with distance from power plants (Levy and Spengler 2000).

The SO_2 dependent variable is calculated from the NRDC data set. For each power plant, the NRDC provides the tons of SO_2 emitted and the megawatt hours of electricity generated in 2004. The SO_2 emissions rates are measured as pounds emitted per megawatt hour. The analysis reduces skewness by using the log of the power plant SO_2 emissions rates. Using log transformations to reduce skewness in the distribution of the dependent variable is common in statistical modeling. For example, Grant et al. (2002) and the other early ecostructural studies of the chemical industry (Grant and Jones 2003; Grant et al. 2004) take the log form of the facility emissions rates to reduce skewness.

Corporate and Community Predictor Variables

The corporate characteristics are the level-2 variables in the multilevel models. The total number of subsidiaries in the parent company is used to measure structural complexity. The subsidiary data are from Dun and Bradstreet. This data source is the most comprehensive, accurate, and reliable source for data on domestic subsidiaries and corporate form (Prechel 2000). The total corporate assets are used to measure corporate size. This measure is consistent with previous research that examines corporate characteristics in relation to financial malfeasance and environmental pollution (Prechel and Morris 2010; Prechel forthcoming). The common dividends paid per share are used to measure capital dependence on shareholders. This measure is consistent with the recent ecostructural research on corporate pollution (Prechel 2009, forthcoming). The data used for the corporate size variable and the capital dependence on shareholders variable are from Compustat. The analysis uses the 2003 and 2004 average of these variables to ensure measurement stability in the financial data.

All demographic data for the local community characteristics are from the 2000 Census. In accord with the geo-unit debates initiated by Anderton et al. (1994), this dissertation examines five-digit zip codes and census tracts separately as two different geo units of analysis. The facility latitude and longitude coordinates recorded in the Acid Rain Program facility unit database at the Clean Air Markets – Data and Maps section of the U.S. EPA are used with the LandView software to identify the zip codes and census tracts for the power plants and to measure the community demographic variables. The LandView software is a commonly used desktop mapping system that provides a wide range of useful data from the U.S. EPA, U.S. Census Bureau, and U.S. Geological Survey.

Based on the claims made by the Black Leadership Forum (2002), the racial minority variable is measured as the percentage of the community that is Black. The poverty variable is measured as the percent families in poverty. The median home value of the specified owner occupied housing units is used to measure the overall value of property in the community. Finally, the data for the local organizing capacity variable are from the Center for Charitable Statistics. This variable is measured as the log of the total number of non-profit organizations in the county where the power plant is located. Using the log form reduces skewness in the distribution of non-profit organizations across counties. This measure is consistent with previous ecostructural research (Grant et al. 2004) and research on local civic engagement (Tolbert et al. 1998) that reduces skewness by using log transformations for similar measures of social capital and organizational networking opportunities at the local county level. To ensure measurement stability, the organizing capacity measure is based on the average number of non-profit organizations in the local county for the years 2003 and 2004.

Control Variables

Four facility control variables and one local demographic control variable are included in the examination. The megawatt generating capacity of the power plant in 2004 is used to control for facility size. The year that the oldest active or retired generating unit began operating at the power plant is used to calculate facility age. These data are from the EIA in the U.S. Department of Energy. For each power plant, the NRDC data are used to calculate the percentage of the total electricity generated that is produced from coal. This measure is used to control for variations in fossil-fuel mix across the different facilities. The EIA databases are used to create the cogeneration facility dummy variable. Any power plant with at least one generating unit classified as a cogeneration unit in 2004 is assigned a value of one. All other power plants are assigned a zero. Finally, the control variable for local population density is measured as the person per square mile in the county where the power plant is located.

DATA COMPLICATIONS

Several complications in the data are worth mentioning. One complication involves three of the 536 power plants that had zero SO_2 emissions for the year 2004. These facilities automatically would have been dropped from the models because log transformations are not calculated for observations with a value of zero. The analysis retains these three facilities by using the average logged SO_2 emissions rates for years 2003 to 2005. As the NRDC (2006) collects much of its generation and emissions data from the EIA in the U.S. Department of Energy and the Acid Rain Program in the U.S. EPA, these sources are used to calculate the 2003 to 2005 emissions rates averages for the three facilities. Alternative exploratory analyses distinguished these facilities with a dummy variable and then simply dropped them as missing values. The results and findings of these exploratory analyses were nearly identical to those shown in the next chapter. The three power plants do not substantively affect the basic conclusions.

Another complication involves the use of zip codes, census tracts, and counties as level-1 variables. The 536 power plants are located in a total of 492 zip codes, 503 census tracts, and 395 counties. Hence, there is on average 1.09 facilities for each zip code, 1.07 facilities for each census tract, and 1.36 facilities for each county[20]. The multilevel models cannot include additional levels grouping the facilities by the geo-units because it is the facilities and not the surrounding geo-unit areas that are nested in the level-2 corporations. In several other exploratory analyses, dummy variables were introduced separately into the models to control for zip codes, census tracts, and counties with more than one power plant. The dummy variables were not significant in any of the models, and their inclusion did not result in other covariates loosing statistical significance.

Finally, another complication involves 28 power plants located in zip codes that do not have Census 2000 data on community variables included in the

[20] Such concerns are not unique to this analysis. It is reasonable to assume that most studies examining local community characteristics for a large number of polluting facilities have at least some cases with more than one facility located in the same zip code, census tract, and county. Yet, studies throughout the literature examine polluting facilities in relation to local demographic variables without hierarchically grouping the facilities by zip code, census tract, and county.

analysis[21]. Also, there are 10 power plants located in census tracts that do not have Census 2000 data on community variables included in the analysis. Some of these zip codes and census tracts had no population at all. Others had some population but had no specified owner occupied housing units. The analysis retains the power plants located in these areas. Each power plant located in one of the problematic zip codes is assigned to an immediately adjoining five-digit zip code in the same zip code tabulation area. Each power plant located in one of the problematic census tracts is assigned to an immediately adjoining census tract in the same county. Consideration was given to simply dropping all facilities located in these areas. Although there were some minor changes primarily involving control variables, none of the significant predictor variables at either level of analysis lost statistical significance in any of the models when these power plants were dropped. The decision was made to retain the power plants located in the problematic areas because their retention prevented the loss of one corporation at level-2 in the multilevel analysis[22].

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[21] Most of these problematic zip codes are designated by the suffix HH after the 3-digit zip code tabulation area assigned by the U.S. Census Bureau. The HH suffix is used where water bodies such as oceans, bays, and large rivers and lakes are assigned to a water zip code tabulation area (U.S. Census Bureau 2000). Some of these problematic zip codes are in large rural areas and undeveloped areas near parks, forests, deserts, or mountains. Zip codes in these areas typically are designated by the suffix XX after the 3-digit zip code tabulation area. Technical documentation by the U.S. Census Bureau (2000) discusses zip codes with an HH suffix and zip codes with an XX suffix in detail. Further information is available on U.S. Census Bureau website.

[22] One corporation is lost at level-2 when dropping the power plants located in the problematic census tracts. The multi-level analysis does not lose any corporation at level-2 when dropping the power plants located in the problematic zip codes.

METHODS AND MODEL STRUCTURE

The multilevel modeling is conducted in Stata using the xtmixed command. The models contain the fixed effects and any random effects necessary to account for significant random deviations other than those associated with the overall error term. The Stata Reference Manual (StataCorp 2005) and other sources on multilevel modeling (Leckie 2010) discuss the differences between fixed and random effects and the use of the Stata xtmixed command to fit linear mixed models for analyses that involve multiple levels of cross-sectional data as well as longitudinal data.

The xtmixed command allows for fitting multilevel models with either maximum likelihood estimation or restricted maximum likelihood estimation. The Stata Reference Manual (StataCorp 2005) suggests restricted maximum likelihood is appropriate for small samples with balanced data, but the question of which estimator to use remains a matter of personal taste. The models in this analysis use maximum likelihood estimation because the data are imbalanced; different numbers of power plants are owned by the different corporations in the analysis.

Social scientists have used multilevel models to study a wide range of phenomena (Mason et al. 1983; Poston and Duan 2000; Steenbergen and Jones 2002; Zhou 2000). Multilevel models – which some methodologists refer to as hierarchical linear models (Raudenbush and Bryk 2002) – have advantages over OLS regression. Multilevel models are appropriate when individual units are nested within larger groups. The assumptions of OLS regression are violated when it fails to account for the nesting of individual units within units at the higher level of analysis and fails to include random effects parameters for coefficients that vary significantly across units at the higher level of analysis. For instance, Raudenbush and Bryk (2002) stress that OLS models are inappropriate for multilevel designs in which several explanatory variables are measured at the organizational level, but the outcome variable is measured at the individual unit level. In sum, multilevel modeling best explains the multilevel effects on the dependent variable when variations exist at both levels of analysis (Leckie 2010; Raudenbush and Bryk 2002; Singer 1998).

Researchers express the notation used for multilevel models in one of two ways. First, some researchers express the models in matrix notation. A basic two-level model that includes the main effects of level-1 and level-2 variables on the dependent outcome variable can be expressed in matrix notation as follows:

$$y = X\beta + Zu + \varepsilon,$$

Where y is a vector of responses, X is a matrix for fixed effects β, Z is a matrix for random effects u, and ε is a vector of errors. The fixed effects are estimated directly and are analogous to standard regression coefficients (StataCorp 2005). The random effects are not estimated directly, but are summarized according to variance components estimated with the residual variance (StataCorp 2005).

The alternative notation used to express the basic two-level model provides a more in-depth elaboration of the nested structure of the data. This approach explicates how the multilevel model is constructed through the specification and combination of different level-1 models and level-2 models. The approach typically specifies the following level-1 and level-2 equations and then combines them by substitution to fit an unconditional null model:

Level-1 Null Model: $Y_{ij} = \beta_{0j} + r_{ij}$

Level-2 Null Model: $\beta_{0j} = \gamma_{00} + u_{0j}$

Combined Null Model: $Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$

The level-1 null model includes only the level-2 parameter β_{0j} to predict the outcome for each level-1 unit Y_{ij}. The outcome variable for the i^{th} level-1 unit in the j^{th} level-2 unit equals the average outcome in level-2 unit j plus the level-1 unit error r_{ij}. In other words, the outcome for individual unit i equals the sum of an intercept β_{0j} for the level-2 unit j and the random error r_{ij} associated with the level-1 unit i that is nested in level-2 unit j.

The overall intercept γ_{00} in the level-2 null model is fixed. It represents the average outcome for the population of all level-1 units i. The u_{0j} represents the random effect that is common to the level-1 units i that are nested in level-2 unit j. Thus, the level-2 intercepts are equal to the sum of the overall mean γ_{00} plus the u_{0j} random deviations from that mean.

The combined null model includes the grand mean γ_{00} with the level-2 effect u_{0j} and the level-1 effect r_{ij}. Methodologists refer to the two random effects parameters u_{0j} and r_{ij} as the τ_{00} and the σ^2, respectively. Their sum equals the total variance of Y_{ij}. The τ_{00} represents the within group variability, and the σ^2 represents the between group variability. The greater the τ_{00} is relative to the σ^2, the greater the proportion of the total variation that is between level-2 units and the greater the importance of using multilevel modeling.

Multiple predictor and control variables may be included in the basic two-level model, and different combinations of fixed and random effects may be specified. Empirically, not every slope necessarily requires a variance component in the random effects portion of the multilevel model (Leckie 2010; Singer 1998; StataCorp 2005). Accordingly, it is not necessary to include a random effects parameter for a slope that does not vary significantly across level-2 units[23]. After all, the null hypothesis that the variance component for a slope equals zero cannot be rejected if the component is insignificantly small[24]. Slopes that do not vary significantly across level-2 units therefore can be constrained as fixed in a relatively simpler and more restricted multilevel model that better fits the data (Leckie 2010; Singer 1998). The failure to include random effects parameters for slopes that vary significantly across level-2 units, on the other hand, can result in false inferences about the fixed effects coefficients in the multilevel model and incorrect conclusions about the hypotheses tested in the multilevel research.

The multilevel models shown in the next chapter include fixed effects coefficients for multiple variables at both level-1 and level-2. The models also include a random effects parameter for one significantly varying slope. The basic model-building notation can be expressed as follows:

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[23] The commonly accepted approach for testing the significance of a variance component is to use a likelihood ratio chi-squared test comparing the model with the variance component to the otherwise same model without the variance component (Leckie 2010; Singer 1998; StataCorp 2005). This basic approach is used to test the significance of variance components in this dissertation. Alternatively, some statistical programs report Wald Z significance tests for variance components that are equal to the estimate divided by its standard error. Singer (1998: p. 351), however, notes critically that: "The validity of these tests has been called into question both because they rely on large sample approximations (not useful with the small sample sizes often analyzed using multilevel models) and because variance components are known to have skewed (and bounded) sampling distributions that render normal approximations such as these questionable."

[24] Also, the multilevel analysis in this dissertation uses the Stata default independent variance-covariance structure that allows for a distinct variance parameter for each random effect, but assumes all covariances are zero. The unstructured alternative that allows all variances and covariances to be distinct is unnecessary if no covariance component is statistically significant.

Level-1 Specified Model: $Y_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_{2j}X_{2ij} + \ldots + \beta_{Pj}X_{Pij} + r_{ij}$

Level-2 Specified Model: $\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + \gamma_{02}W_{2j} + \ldots + \gamma_{0Q}W_{Qj} + u_{0j}$

$$B_{1j} = \gamma_{10} + u_{1j}$$

$$B_{2j} = \gamma_{20}$$

$$\begin{array}{cc} . & . \\ . & . \\ . & . \end{array}$$

$$B_{Pj} = \gamma_{P0}$$

Combined Specified Model: $Y_{ij} = \gamma_{00} + \gamma_{01}W_{1j} + \gamma_{02}W_{2j} + \ldots + \gamma_{0Q}W_{Qj} +$

$\gamma_{10}X_{1ij} + \gamma_{20}X_{2ij} + \ldots + \gamma_{P0}X_{Pij} + u_{0j} + u_{1j}X_{1ij} + r_{ij}$

Multilevel modelers refer to the level-1 equations and level-2 equations as within group equations and between group equations, respectively. The level-1 model includes β_{0j} representing the intercept or the average value of Y_{ij} for level-2 unit j and the β_{Pj} representing the slopes of variables X_{Pij} for the level-1 units i nested in level-2 unit j. The level-1 model also includes the random error term r_{ij} for the individual level-1 unit i in level-2 unit j.

The level-1 intercept β_{0j} and slopes β_{Pj} are modeled as outcomes in the level-2 equations. The γ_{00} and the γ_{0Q} in the level-2 model are used to predict β_{0j}, and the γ_{P0} are used to predict B_{Pj}. The significantly varying slope B_{1j} equals γ_{10} plus the random error term u_{1j}. As no other B_{Pj} varies significantly across level-2 units, all other B_{Pj} are equal to γ_{P0} without the addition of random error terms.

The combined model equation now specifies the main effects of the level-2 variables W_{Qj} and the level-1 variables X_{Pij} on the dependent variable Y_{ij}[25]. The overall intercept γ_{00} is the grand mean of Y_{ij}, and the γ_{0Q} represent the fixed effects of level-2 variables W_{Qj} on Y_{ij}. The X_{Pij} are level-1 predictor and control variables for individual unit i in level-2 unit j, and the γ_{P0} represent the fixed effects of level-1 variables X_{Pij} across level-2 units. The random effects portion now includes u_{0j} and r_{ij} along with $u_{1j}X_{1ij}$ for the random slope β_{1j} that varies significantly across level-2 units.

[25] This research tests only the main effects of the explanatory variables on the dependent outcome variable. Some multilevel modeling examples also include cross-level interaction terms in the level-2 equations for B_{Pj}. Nonetheless, there are many examples of multilevel models that do not include such terms. This analysis does not explore potential cross-level interaction effects. The models do not converge when all cross-level interaction terms involving all level-2 variables and all level-1 variables are included. Development of further research questions for future studies is being considered to identify specific cross-level interaction terms of theoretical interest.

CHAPTER IV

RESULTS AND FINDINGS

DESCRIPTIVE STATISTICS

Table 4.1 reports descriptive statistics for the variables used in the multilevel models. The 536 power plants, on average, emitted SO_2 at a rate of 5.79 pounds per megawatt hour. Table 4.1 shows that the mean of the logged form of the dependent variable is -1.42[26].

The table next reports descriptive statistics for level-2 variables characterizing the 51 corporate structures in which the power plants are grouped. The mean value of the total assets expressed in $100 million dollars for the 51 corporate power producers is 173.59. The mean value of the total number of subsidiaries for the 51 ultimate parent companies is 29.78. The mean value of the dividend payments by the 51 corporations is 1.09. In other words, these corporations on average possess $17,359 million dollars in total assets, have 29.78 subsidiaries in the corporate structure, and pay $1.09 dollars in dividends per share.

[26] All facilities in this analysis have greater than zero pounds of SO_2 emitted per megawatt hour. The mean value of the logged dependent variable is negative because log transformations change positive values between zero and one to negative values. Metrics other than megawatt hour could be used to decrease the size of the denominator in the calculation of the dependent variable and thereby increase all values in the raw distribution so that facilities with values between zero and one would have values greater than one. The mean of the log dependent variable measure then would be positive, and there would be no substantive change in the findings. This analysis uses megawatt hour as the metric to calculate the emissions rates since megawatt hour is reported commonly in documentation by NRDC and government agencies.

Table 4.1. Descriptive Statistics of Variables in the Multilevel Models

Variable Measure	N	Mean	SD
Dependent Outcome Variable			
Facility SO_2 Emissions Rates (Log)	536	-1.42	3.55
Facility SO_2 Emissions Rates	536	5.79	8.59
Level-2 Corporate Predictor Variables			
Total Assets in $100 Million Dollars	51	173.59	130.80
Total Number of Subsidiaries	51	29.78	25.31
Dividends Paid Per Share in $Dollars	51	1.09	0.77
Level-1 Local Community Predictor Variables			
Community Percent Black (ZIP Codes)	536	11.92	18.24
Community Percent Black (Census Tracts)	536	11.68	19.84
Community Percent Families Living in Poverty (ZIP Codes)	536	10.14	7.26
Community Percent Families Living in Poverty (Census Tracts)	536	10.34	8.96
Community Median Home Value in $10, 000 Dollars (ZIP Codes)	536	10.53	6.00
Community Median Home Value in $10, 000 Dollars (Census Tracts)	536	10.80	6.95
Total Number of Non-Profit Organizations in County (Log)	536	6.62	1.47
Total Number of Non-Profit Organizations in County	536	2056.2	3701.3
Level-1 Power Plant and Local Control Variables			
Facility Size (Log)	536	6.25	0.96
Facility Size	536	759.28	639.48
Facility Age	536	31.17	21.26
Facility Percent Coal Generation	536	36.17	47.09
Cogeneration Facility	536	0.07	0.25
Local Population Density (/100)	536	9.45	23.71

Descriptive statistics of the original form of the logged variables used in the analysis are indented and shown for reference.

Table 4.1 next reports descriptive statistics for the zip code and census tract measures of the level-1 variables characterizing the communities in which the facilities are located. Across the power plants, the average value for the percentage of the population that is Black in the community is 11.92 when zip codes are used as the geo-unit of analysis and 11.68 when census tracts are used as the geo-unit of analysis. Across the facilities, the average value for percent families in poverty is 10.14 using zip codes as the community geo-unit and 10.34 using census tracts as the community geo-unit. Across the power plants, the mean value for the community median home value expressed in

$10,000 dollars is 10.53 using zip codes and 10.80 using census tracts. This equates to an average value of $105,300 using zip codes and an average value of $108,000 using census tracts. Finally, across the facilities, the mean value for the total number of non-profit organizations in the local county is 2,056. Table 4.1 shows that the mean of its logged form is 6.62.

Lastly, Table 4.1 reports descriptive statistics for the level-1 power plant and local demographic control variables. Across the power plants, the average facility size measured by nameplate generating capacity is 759.28 megawatts. The table shows that the mean value of its logged form is 6.25. The mean value for the power plant age measure across the facilities is 31.17. The mean value across the facilities for the percentage of the total electricity generated that is produced from coal is 36.17. The mean value of .07 for the cogeneration dummy variable indicates that seven percent of the power plants in the study group are cogeneration facilities. Across the facilities, the mean value for the county population density measure expressed in hundreds is 9.45. This number equates to 945 persons per square mile.

THE MULTILEVEL ANALYSIS

Appendix A at the end of the dissertation shows preliminary OLS models parallel to the multilevel models in this chapter. The OLS models include all the same variables at both levels of analysis, but do not allow for intercepts or slopes to vary across level-2 units. The discussion here mentions these models because violating the assumptions of OLS models can lead to results that are different from those of the more appropriate multilevel models. Multicollinearity is not a problem in the OLS models. With the exception of one squared term in one basic model, all tolerance levels for all variables in all models are above .50 and all variance inflation factors are below 2.00. Heteroscedasticity is a problem. The Stata Breush-Pagan/Cook-Weisberg tests indicate significant heteroscedasticity for all models in Appendix A. This suggests that there is a lack of independence among observations. This feature of the data makes multilevel models, which structurally group level-1 units within level-2 units, preferable and necessary.

Table 4.2 shows the results and findings of the multilevel models using zip codes as the geo-unit. The null model is a one-way random effects ANOVA model. Model 1 includes all variables at level-1, but corporate size as the only variable at level-2. Model 1 thus is similar to the model in Grant et al. (2002) that includes size as the only firm variable explaining emissions rates at chemical plants. Model 2 is the model of primary interest. It includes all level-1 and level-2 variables shown in Table 4.1. Model 3 is the same as Model 2 except it includes a squared term for percent families in poverty since some researchers suggest poverty and income variables have quadratic relationships with air pollution (Brooks and Sethi 1997; Daniels and Friedman 1999; Pastor et al. 2005).

Table 4.2. Mixed-Effects Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: ZIP Codes for Community Variables

	Null Model	Model 1	Model 2	Model 3
Fixed Effects				
Intercept	-1.3010 ***	-4.3234 ***	-4.7350 ***	-5.0425 ***
	[.2536]	[.7509]	[.7536]	[.7258]
Corporate Characteristics				
Total Assets		.0003	-.0009	-.0009
(in $100 Million Dollars)		[.0008]	[.0009]	[.0009]
Total Number of Subsidiaries			.0111 **	.0111 **
			[.0047]	[.0047]
Dividends Paid Per Share			.3153 **	.3187 **
(in $Dollars)			[.1194]	[.1194]
Local Community Characteristics				
Community Percent Black		.0115 *	.0105 *	.0083
		[.0059]	[.0058]	[.0059]
Community Percent Families		-.0402 **	-.0376 **	-.0579 ***
Living in Poverty		[.0158]	[.0157]	[.0189]
Community Percent Families				.0020 *
Living in Poverty Squared				[.0010]
Community Median Home Value		-.0122	-.0101	-.0160
(in $10 Thousand Dollars)		[.0188]	[.0187]	[.0188]
Total Number of Non-Profit		-.1619 **	-.1620 **	-.1851 **
Organizations in County (Log)		[.0677]	[.0673]	[.0681]
Power Plant and Local Controls				
Facility Megawatt Nameplate		.2021 *	.1883 *	.1939 *
Generating Capacity (Log)		[.0915]	[.0906]	[.0903]
Facility Age		.0407 ***	.0409 ***	.0412 ***
		[.0054]	[.0053]	[.0053]
Facility Percent Coal Generation		.0488 ***	.0483 ***	.0481 ***
		[.0022]	[.0022]	[.0022]
Cogeneration Facility		-.5419	-.4238	-.3610
		[.3491]	[.3496]	[.3498]
County Population Density (/100)		.0059	.0052	.0062
		[.0043]	[.0043]	[.0043]
Random Effects Parameters				
Variance (Facility Age)		.0002 *	.0002 **	.0002 **
		[.0001]	[.0001]	[.0001]
Variance (Constant)	1.8510 ***	.0367	.0000003	.0000007
	[.6235]	[.0707]	[.000004]	[.0002]
Variance (Level-1 Residual)	10.2984	3.4222	3.3820	3.3533
	[.6582]	[.2214]	[.3574]	[.2142]
Model Fit Statistics				
Wald Chi2	.	1037.50 ***	1112.56 ***	1117.54 ***
AIC	2824.91	2238.90	2232.58	2230.85
BIC	2837.76	2298.87	2301.12	2303.68
N Level-2	51	51	51	51
N Level-1	536	536	536	536

*** P<.001; ** P<.01; * P<.05 one-tail significance reported for fixed effects.
One-tail LR Chi2 significance reported for random effect variance components (facility age and constant) and Wald model fit statistic.

Examination of the random effects parameters in the null model is a precondition for multilevel modeling. The null model indicates that the between corporation level-2 variance for the random intercept is estimated as 1.85 and that the within corporation level-1 facility residual variance is estimated as 10.30. The .001 significance level of the variance component for the random intercept indicates that corporations differ in terms of their average facility SO_2 emissions rates and that multilevel modeling is appropriate[27]. A variance partition coefficient is calculated by dividing the variance estimate for the random intercept over the sum of the estimated intercept variance component and the estimated level-1 residual variance component. This coefficient, which some methodologists refer to as the intra-class correlation coefficient, equals .15 for the null model. Thus, although much of the variation in power plant SO_2 emissions rates occurs at the facility level within corporations, a substantial 15 percent of the variance is attributed to differences among corporations.

The fixed effects coefficients for the explanatory variables included in Model 1, Model 2, and Model 3 are used to test the hypotheses stated in Chapter II of the dissertation. Before focusing on the fixed effects, however, further discussion of the random effects parameters and the overall model fit statistics is required.

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[27] The significance of the variance component for the random intercept is derived from a likelihood ratio chi-squared test comparing the null model shown in Table 4.2 to an equivalent null single-level model. Interested readers can see Leckie (2010) for further details on how to test the variance estimate of the intercept for statistical significance in an unconditional null model.

The slope for power plant age varies significantly across corporations in all three models. No other slope coefficient for any other variable varies significantly in any model[28]. In accordance with Leckie (2010) and Singer (1998), all other slopes therefore are constrained as fixed. The models are estimated using the independent variance-covariance structure, which is the default in Stata. The unstructured alternative is not used because the covariance component for the random intercept and the randomly varying slope is not significant in any model[29].

Concerning overall model fit, the Wald chi-squared statistics are significant at the .001 level in Model 1, Model 2, and Model 3. The fixed effects coefficients, taken jointly, are significant in each of the three models. Moreover, the variance estimate of the random intercept is reduced by almost 100 percent when the explanatory variables are included in the fixed effects portion of the models and the variance component for the facility age slope is included in the random effects portion of the models. The random effect estimate of the level-1 facility

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[28] A separate likelihood ratio chi-squared test was conducted for each explanatory variable to determine if its slope varies significantly. For each predictor and control variable, the test compared the model with the variance component for the slope in question to the otherwise same model without the variance component for the slope in question. Many sources have discussed the use of likelihood ratio tests to establish whether a variance component for any given slope should be included in the random effects portion of a multilevel model (Leckie 2010; Singer 1998; StataCorp 2005).

[29] A likelihood ratio chi-squared test also was conducted in each of the models to determine if the unstructured variance-covariance structure should be used to allow for random intercepts and random slopes to covary. The basic test was conducted by comparing the model with the covariance component to the otherwise same model without the covariance component. As the covariance component was insignificantly small in each model, the three models were fit using the Stata independent covariance structure that by default assumes all covariances are zero.

residual variance is reduced by about two-thirds in each of the three models. All of this indicates that the multilevel modeling in Table 4.2 fits the data effectively. Finally, the Akaike's Information Criterion (AIC) improves slightly from Model 1 to Model 2 to Model 3. The Schwarz's Bayesian Information Criterion (BIC) indicates otherwise because the BIC has a higher penalty for the increased number of parameters estimated.

The following assessment of the fixed effects coefficients in Table 4.2 focuses separately across the three models on each of the variables used to test each of the hypotheses. The significance of each predictor and control variable is discussed for all three models. The interpretation of the magnitude of the predictor variables is based on Model 2.

The coefficient for the level-2 corporate size variable is not significant in any of the three models. In other words, the coefficient is not statistically different from zero in any model. The total assets of the power-producing corporations do not have an effect on the SO_2 emissions rates at the facility level. The results shown in Table 4.2 therefore do not provide any support for the first hypothesis.

The level-2 coefficient for the total number of subsidiaries in the corporate structure is positive and significant at the .01 level in Model 2. To quantify this relationship, there is on average a 1.12 percent increase in facility SO_2

emissions rates for each additional subsidiary in the overall structure of the ultimate parent company ((exp.(.0111)-1) * 100 = 1.12). The total subsidiaries coefficient also is positive and significant at the .01 level in Model 3. These findings strongly support Hypothesis 2.

Regarding the third hypothesis, the level-2 coefficient for corporate dividend payments is positive and significant at the .01 level in Model 2. For an additional dollar of dividends paid per share, there is on average an expected 37.07 percent increase in power plant SO_2 emissions rates ((exp.(.3153)-1) * 100 = 37.07). The level-2 dividend payments coefficient also is positive and significant at the .01 level in Model 3. These findings (i.e., statistical significance and large magnitude effect) are consistent with Prechel (2009) and provide strong support for Hypothesis 3.

The level-1 coefficient for community percent Black is positive and significant at the .05 level in Model 1. The positive coefficient for percent Black also is significant at .05 when the level-2 subsidiary and dividend variables are entered into Model 2. With each one percentage point increase in percent Black, there is on average a 1.06 percent increase in power plant SO_2 emissions rates ((exp.(.0105)-1) * 100 = 1.06). Although these findings in Table 4.2 provide some empirical support for Hypothesis 4, the coefficient for percent Black loses significance when the squared term for poverty is entered into Model 3.

Contrary to Hypothesis 5, the coefficient for community percent families in poverty is negative and significant at the .01 level in Model 1. It also is negative and significant at the .01 level in Model 2. For a one percentage point increase in percent families in poverty, facility SO_2 emissions rates on average decrease by 3.83 percent ((exp.(-.0376)-1 * 100 = -3.83). The negative coefficient for percent families in poverty is significant at the .001 level when its square is included in Model 3[30]. The positive coefficient for the squared term is significant at the .05 level and provides some support for researchers who suggest that quadratic functions are appropriate to model the non-linear relationships that poverty and income variables have with pollution in general (Boer, Pastor, Sadd, Snyder 1997; Brooks and Sethi 1997; Daniels and Friedman 1999; Pastor 2005). Specifically, the effects of percent families in poverty on the facility SO_2 emissions rates follows a U-shaped pattern that turns positive at the threshold value of 14.48 percent families in poverty[31].

The level-1 coefficient for community median home value is not significant in Model 1, Model 2, or Model 3. Hence, using zip codes as the community geo-unit of analysis, the median home value in the community does not have a

[30] Percent families in poverty and its square are measured as deviations from the grand mean in the third model. This basic technique is used commonly to minimize multicollinearity problems that are a potential concern when researchers include squared terms to model quadratic functions.

[31] The threshold value at which the variable effects of the quadratic function $ax^2 + bx + c$ turns in direction can be calculated at $x = -b/2a$.

statistically significant effect on the rates at which power plants emit SO_2. The modeling results in Table 4.2 provide no support for Hypothesis 6.

All three models support Hypothesis 7. In Model 1, the coefficient for the log of the total number of non-profit organizations in the local county is negative and significant at the .01 level. Neither the direction nor the significance of the coefficient is affected by the inclusion of the level-2 subsidiary and dividend variables in Model 2. For each one percent increase in the number of non-profit organizations, there is on average a .16 percent decrease in facility SO_2 emissions rates ((= -.162 * ln(1.01) * 100). The negative coefficient for the number of non-profit organizations remains significant at the .01 level when the squared term for poverty is included in Model 3. These findings indicate local organizing capacity has a negative effect on power plant SO_2 emissions rates.

Finally, the fixed effects coefficients for several of the level-1 control variables are significant. The coefficient for facility size is positive and significant at the .05 level in all three models. The coefficient for facility age is positive and significant at the .001 level in all of the models. The coefficient for facility percent coal generation also is positive and significant at the .001 level in each of the three models. Neither the cogeneration facility dummy variable nor the local population density variable is significant in any model.

Table 4.3 shows the results and findings of the same models from Table 4.2 using census tracts as the community geo-unit of analysis. The unconditional null model is shown again only for reference. The models used to test the hypotheses now are labeled Model 1a, Model 2a, and Model 3a. The assessment of the results and findings from these three models follows the same format as the previous discussion from the corresponding three models in Table 4.2 where zip codes are used as the community geo-unit of analysis[32].

As in Table 4.2, the multilevel models shown in Table 4.3 fit the data appropriately. The Wald chi-squared statistics for all three of the models are significant at the .001 level. Taken jointly, the fixed effects coefficients are significant in Model 1a, Model 2a, and Model 3a. Compared to the unconditional null model, the variance estimate of the random intercept again is reduced by almost 100 percent when the predictor and control variables are included in the fixed effects portion of the models and the variance component for the facility age slope is included in the random effects portion of the models. The estimate of the level-1 facility residual variance again is reduced by about two-thirds in each of the three models. Lastly, the AIC and BIC improve noticeably compared to the unconditional null model.

[32] Grant et al. (2002) show their results and findings using only zip codes to measure community demographic variables, while noting that their results and findings do not differ substantially when census tract measures are used instead. However, this study shows that results and findings involving community demographic variables and power plant SO_2 emissions rates do indeed differ when census tracts are used instead of zip codes as the community geo-unit of analysis.

Table 4.3. Mixed-Effects Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: Census Tracts for Community Variables

	Null Model	Model 1a	Model 2a	Model 3a
Fixed Effects				
Intercept	-1.3010 ***	-4.3159 ***	-4.7220 ***	-4.9081 ***
	[.2536]	[.7484]	[.7511]	[.7328]
Corporate Characteristics				
Total Assets		.0005	-.0007	-.0007
(in $100 Million Dollars)		[.0009]	[.0009]	[.0009]
Total Number of Subsidiaries			.0121 **	.0122 **
			[.0048]	[.0048]
Dividends Paid Per Share			.3066 **	.3092 **
(in $Dollars)			[.1216]	[.1218]
Local Community Characteristics				
Community Percent Black		.0043	.0031	.0032
		[.0054]	[.0053]	[.0053]
Community Percent Families		-.0218 *	-.0199	-.0280 *
Living in Poverty		[.0124]	[.0123]	[.0167]
Community Percent Families				.0004
Living in Poverty Squared				[.0005]
Community Median Home Value		-.0338 *	-.0328 *	-.0352 *
(in $10 Thousand Dollars)		[.0157]	[.0156]	[.0159]
Total Number of Non-Profit		-.1336 *	-.1326 *	-.1349 *
Organizations in County (Log)		[.0670]	[.0668]	[.0668]
Power Plant and Local Controls				
Facility Megawatt Nameplate		.1825 *	.1689 *	.1672 *
Generating Capacity (Log)		[.0921]	[.0913]	[.0913]
Facility Age		.0414 ***	.0415 ***	.0412 ***
		[.0055]	[.0054]	[.0054]
Facility Percent Coal Generation		.0485 ***	.0480 ***	.0480 ***
		[.0023]	[.0022]	[.0022]
Cogeneration Facility		-.6538 *	-.5311	-.5149
		[.3463]	[.3473]	[.3479]
County Population Density (/100)		.0077 *	.0071	.0068
		[.0044]	[.0044]	[.0044]
Random Effects Parameters				
Variance (Facility Age)		.0002 **	.0002 ***	.0002 ***
		[.0001]	[.0001]	[.0001]
Variance (Constant)	1.8510 ***	.0284	.0000003	.0000002
	[.6235]	[.0708]	[.000002]	[.00006]
Variance (Level-1 Residual)	10.2984	3.4013	3.3624	3.3571
	[.6582]	[.2201]	[.2162]	[.2149]
Model Fit Statistics				
Wald Chi2	.	1005.93 ***	1079.88 ***	1079.02 ***
AIC	2824.91	2239.93	2233.39	2234.87
BIC	2837.76	2299.91	2301.93	2307.70
N Level-2	51	51	51	51
N Level-1	536	536	536	536

*** P<.001; ** P<.01; * P<.05 one-tail significance reported for fixed effects.
One-tail LR Chi2 significance reported for random effect variance components (facility age and constant) and Wald model fit statistic.

Table 4.3 shows that there is no change from Table 4.2 in terms of the level-2 coefficients used to test the hypothesized effects of the corporate characteristics on the power plant SO_2 emissions rates. The level-2 coefficient for corporate size again is statistically insignificant in all three models. Both the level-2 coefficient for total number of subsidiaries and the level-2 coefficient for dividend payments again are positive in direction and significant at the .01 level when they are included in Model 2a. The coefficients for these corporate-level variables again remain positive and significant at the .01 level in Model 3a. These results and findings corroborate those in Table 4.2. Neither Table 4.2 nor Table 4.3 provides any support for Hypothesis 1. The findings shown in both of these tables provide strong empirical evidence supporting Hypothesis 2 and Hypothesis 3.

There is no longer any support for Hypothesis 4 when census tracts are used as the community geo-unit of analysis. The level-1 coefficient for community percent Black loses statistical significance in Model 1a and Model 2a. As in Table 4.2, the percent Black coefficient is insignificant in Model 3a. In sum, the results shown in Table 4.3 refute the limited empirical evidence supporting the fourth hypothesis that was shown in Table 4.2.

The level-1 coefficient for community percent families in poverty is negative and significant at the .05 level in Model 1a of Table 4.3. The negative coefficient loses significance in Model 2a, but regains significance at the .05 level when the squared term for percent families in poverty is included in Model 3a. Hence, no model in either Table 4.2 or Table 4.3 supports the hypothesized positive linear relationship between percent families in poverty and power plant SO_2 emissions rates. As the squared term for percent families in poverty is not significant in Model 3a of Table 4.3, the quadratic effect suggested by the significant squared term in Table 4.2 is not corroborated.

Table 4.3 shows that the level-1 coefficient for community median home value is negative as hypothesized and significant at the .01 level in all three of the models when the census tracts are used as the community geo-unit of analysis. For a ten thousand dollar increase in the median home value, there is on average a 3.33 percent decrease power plant SO_2 emissions rates ((exp.(-.0328)-1) * 100 = -3.33). In contrast to the insignificant results shown in Table 4.2, these findings do support the sixth hypothesis.

Supporting the seventh hypothesis, all three models in Table 4.3 indicate that the coefficient for the total number of non-profit organizations in the county is negative and significant at the .05 level. There is on average a .13 percent decrease in power plant SO_2 emissions rates for each one percent increase in the number of non-profit organizations. The findings of Table 4.3 thus corroborate the significant negative effects shown in Table 4.2 and provide consistent support for Hypothesis 7.

The coefficients for the level-1 control variables generally are in agreement with those shown in Table 4.2. The coefficient for facility size again is positive and significant at the .05 level in all three models. The coefficients for both facility age and percent coal generation again are positive and significant at the .001 level in all of the models. The only differences from Table 4.2 in terms of control variables is that the negative coefficient for the cogeneration facility dummy variable and the positive coefficient for the local population density control variable both are significant at the .05 level in Model 1a of Table 4.3. In concurrence with the results shown in Table 4.2, neither the cogeneration facility dummy variable nor local population density is significant in either Model 2a or Model 3a.

Finally, Appendix B shows the same three models from Table 4.2 and Table 4.3 after dropping the observations where immediately adjoining zip codes and census tracts had to be used because power plant facilities are located in zip codes and census tracts that do not have Census 2000 data for community variables in the analysis. Table B.1 corresponds to Table 4.2. Table B.2 corresponds to Table 4.3.

Table B.1 and Table B.2 indicate that dropping the facilities located in the problematic geo-unit areas does not affect the level-2 coefficients used to test the corporate hypotheses. The total assets coefficient is not significant in any of the models. The coefficients for total number of subsidiaries and dividend payments both are significantly positive in Table B.1 and Table B.2. This all corroborates the results and findings shown this chapter. There is no support for Hypothesis 1. There is consistently strong support for Hypothesis 2 and Hypothesis 3.

None of the level-1 predictor variables loses statistical significance in any model of Table B.1 or Table B.2. Nonetheless, the insignificant positive coefficient for percent Black in Model 3 of Table 4.2 does become significant at the .05 level in Model 3 of Table B.1. This provides some additional support for Hypothesis 4. Also, the insignificantly negative percent family in poverty coefficient in Model 2a of Table 4.3 becomes significant at the .05 level in Model 2a of Table B.2. This provides more evidence refuting the hypothesized linear relationship between poverty and emissions rates.

There are several differences involving level-1 control variables. The facility size variable is not significant in any model of Table B.1. The negative coefficient for the cogeneration facility variable is significant in Model 1 of Table B.1, and it is significant in all three models of Table B.2. The positive coefficient for local population density gains significance in all models of Table B.1, but loses significance in Model 1a of Table B.2. Although these differences in control variables are worth mentioning, they do not affect the assessment of either the corporate hypotheses or the local community hypotheses.

CHAPTER V

SUMMARY AND CONCLUSIONS

The conceptual framework guiding this dissertation has drawn from ecostructural theory, organizational resource dependence theory, and leading theories of environmental inequality. The multilevel examination is important for several reasons. First, including corporate characteristics in the analysis is important because managers of corporations that own polluting facilities make decisions regarding production priorities and pollution abatement technologies that affect day-to-day operations at the facilities. Second, including the organizing capacity variable in the examination of community characteristics is important because of the deterrent effects that local-based organizations can have on pollution. Third, the inclusion of facility characteristics as control variables increases confidence in the interpretation of findings. The following sections summarize the findings at each level of analysis and discuss implications for research and public policy.

SUMMARY DISCUSSION

Discussion of Corporate Findings

The findings showing that the total number of subsidiaries in the corporate structure relates positively to power plant SO_2 emissions rates are consistent with ecostructural theory (Prechel forthcoming; Prechel and Zheng 2009). These findings substantiate the basic argument that the multilayer-subsidiary form has created dependencies, incentives, and opportunities that affect ecoefficiency. The structural complexity of the multilayer-subsidiary form makes corporate behavior difficult to monitor and regulate, while the liability firewalls protect parent companies from liability risks involving their legally independent subsidiaries. Hence, this corporate form allows and encourages managers to externalize pollution costs.

The findings also show that the corporate dividend payments have a significant positive effect on power plant SO_2 emissions rates. These findings are consistent with the arguments of ecostructural theorists and other critical environmental sociologists (Prechel 2009; Schnaiberg and Gould 1994). The multilayer-subsidiary form has made corporate managers dependent on large institutional investors and other wealthy shareholders who purchase corporate securities. This new layer of capital dependence has created incentives and opportunities for corporate managers to maximize shareholder wealth instead of investing in pollution abatement technologies (Prechel forthcoming).

These corporate-level findings have implications for both research and public policy. Interdisciplinary scientists have concentrated much attention on environmental pollution and other policy problems associated with energy and the pursuit of sustainability (Bent et al. 2002; Lee 2002). Ecostructural theory and the findings of this dissertation suggest that environmental scientists must focus specifically on examining characteristics of the complex organizations in which polluting facilities are embedded. Only then can they fully understand the causal factors that explain variations in pollution emitted by the facilities, and only then can they advise policy makers on how to create a political-legal environment in which sustainable development practices can be implemented to protect the human population and the natural environment from pollution.

Critical environmental sociologists maintain that corporations are a threat to sustainable development (Schnaiberg, Pellow, and Weinberg 2003). Accordingly, policy makers have failed to address the ecological impacts of corporate activities adequately because the economic interests of corporations hold priority over environmental concerns throughout the policy formation process. In the case of the electrical power industry, ecostructural research recognizes that the economic and energy crises of the 1970s and 1980s compelled the state to align its energy policy agenda with the corporate agenda of capital accumulation (Prechel forthcoming). The resulting deregulatory policies (e.g., Energy Policy Act of 1992) have allowed and encouraged corporate power producers to externalize pollution costs rather than making investments to improve on ecoefficiency (Prechel 2009).

Policy makers must strengthen the environmental regulatory framework to create conditions that encourage ecoefficiency and thereby promote sustainable development. Enacting policies to regulate pollution at the facility level is necessary but not sufficient because many decisions regarding production priorities and pollution abatement technologies occur at the meso-organizational level in the corporations that own the facilities. Policy makers must address the dependencies, incentives, and opportunities created by corporate structures and the embeddedness of corporate structures in the political-legal environment. Specifically, they must address the structural complexity and liability firewalls of corporations in the multilayer-subsidiary form and the institutional structure of speculative finance that have allowed and encouraged managers to externalize pollution costs during the contemporary era.

Discussion of Local Community Findings

The local community examination provides limited support for the environmental racism argument advanced by environmental justice advocates. The results show no relationship between power plant SO_2 emissions rates and percent Black when using census tracts as the geo unit of analysis. On the other hand, this relationship is significant when using zip codes and does support the argument that Black communities are disparately affected by pollution. The widely critiqued civil rights strategies that promote Title VI and the disparate impact standard (Clinton 1994; Lee 1997) are applicable – at least potentially – as remedies for the unequal mitigation and regulation of risks at power plants and other types of polluting facilities. As previously emphasized, however, actual attempts to apply these strategies to remedy environmental disparities that adversely affect minorities have been unsuccessful. The discussion here follows Gorden and Harley (2005) in suggesting that environmental justice advocates should focus less attention on trying to transform the legal system by applying civil rights laws in environmental justice cases and more attention on organizing minority populations so that they can effectively oppose those responsible for polluting their communities.

The significant negative relationship between power plant SO_2 emissions rates and percent families in poverty does not support the argument that poor communities with little sociopolitical capacity bear the burdens of pollution unequally. Contrary to the linear hypothesis, power plants located in communities with larger percentages of families in poverty appear to have lower pollution rates than power plants located in communities with smaller percentages of families in poverty. Nonetheless, the significant positive relationship between power plant SO_2 emissions rates and the squared term for percent families in poverty – using zip codes – provides some evidence suggesting that at a certain threshold the very poorest communities with the very least ability to resist pollution bear a greater share of pollution. This is consistent with previous research that indicates poverty and income variables have quadratic relationships with air pollution and other types of pollution (Boer et al. 1997; Brooks and Sethi 1997; Daniels and Friedman 1999; Pastor et al. 2005).

Although the community analysis using zip codes finds no relationship between power plant SO_2 emissions rates and median home values, the significant negative relationship observed when using census tracts is consistent with Touché and Rogers (2005) and supports the argument that pollution abatement tends to be remiss at facilities located in communities with relatively low property values. These findings cannot be justified under the legal legitimacy assumption that underpins the standard rational choice explanation of environmental inequality. Managers in industry do not have a legal right to decide where they can cut pollution abatement costs simply based on the property values of the communities in which their existing facilities are located.

Any potential argument implying that it is rational for managers to violate emissions laws would be contingent on sociopolitical factors to explain why they tend to violate emissions laws at facilities located in communities with low property values but not at facilities located in communities with high property values. All else equal, managers cannot reduce pollution abatement costs any more by breaking laws at polluting facilities located in low property value communities than they can by breaking laws at polluting facilities located in high property value communities. The interpretation here follows the path of least resistance theory by recognizing that low property value communities have little capacity to oppose managers who fail to comply with emissions laws and regulators who fail to enforce compliance with emissions laws. As previously discussed, this is a sociopolitical explanation more than a rational choice explanation because resistance involves power. The basic concept of power, according to many sociologists, exists in social relationships and entails more than standard rational choice factors that center on individual calculations of cost efficiency and economic utility.

Finally, all models show that there is a significant negative relationship between power plant SO_2 emissions rates and the logged number non-profit organizations in the local county. These findings indicating that local organizations have deterrent effects on pollution are consistent with the sociopolitical model and the arguments of many different scholars in the environmental sociology and social movement literature. They also are consistent with ecostructural theory (Grant et al. 2004), which recognizes that the organizational structures of local communities can influence the behavior of corporations and other types of polluting organizations.

In sum, the findings of the local community analysis coincide with the organizational theme of this dissertation. Regardless of the demographic characteristics of the communities (e.g., Black or poor White), local non-profit organizations make a significant difference that explains variation in environmental pollution. Research scientists studying pollution emitted by power plants and other types of polluting facilities must include local organizational factors in their analyses so that they can better explain variations in distributions of pollution. In addition, environmental justice scholars must place greater emphasis on local organizational factors in both their research on pollution and their strategies to remedy inequalities involving pollution.

Lastly, the differences in demographic findings observed when using zip codes and census tracts follow in accordance with much literature that suggests relationships involving environmental pollution and demographic characteristics are contingent on the geo unit of analysis. This presents a theoretical problem because the demographic findings do not consistently support any model of environmental inequality. The contingency of these findings on the geo unit of analysis also is problematic for environmental justice advocates who have long argued that stronger federal legislation (i.e., an Environmental Justice Act) must be passed to address environmental inequality in minority and other distressed communities (Bullard 1994). After all, it would be easier to convince federal policy makers to enact legislation that addresses environmental inequality if the evidence consistently demonstrated the existence of environmental inequality.

Future research could perhaps use an alternative methodological approach to measure the demographic composition of the communities where the facilities are located. As discussed by Liu (2001), the basic approach would entail using Geographic Information System Technologies to measure the demographic composition within circular areas around the facilities. There are, however, considerable difficulties that inhibit the potential application of this approach.

One problem with this alternative approach for measuring the demographic characteristics would involve specifying the size of the circular areas. Relatively small areas could best represent the communities where the facilities are located in many cases, but the number of cases with zero population living near the facilities would increase progressively with decreases in the size of the areas around the facilities. Another problem is that the Landview software used in this dissertation would not be able to calculate the median home values within circular areas around the facilities.

Nonetheless, future studies could perhaps address these problems by using Landview with other geographic information system technologies to measure and compare the median home values and other demographic characteristics within circular areas of various diameters (e.g., 2.5 miles, 5 miles, 10 miles, and 15 miles). Analyses examining pollution rates in relation to demographic characteristics then could be conducted. There is of course no guarantee that findings obtained when using circular areas of different sizes to measure the demographic characteristics would be more consistent than findings obtained when using the conventional zip codes and census tracts to measure the demographic characteristics. Hence, there is no guarantee that the alternative circular area approach would produce consistent demographic findings to support any theoretical model of environmental inequality or to convince policy makers that stronger federal legislation is needed to remedy environmental inequality.

Discussion of Control Variables

Several facility control variables are significant in all of the models. Specifically, every model indicates that the size of power plants, the age of power plants, and the percent coal generation at power plants have significant effects on power plant SO_2 emissions rates. Although the hypotheses in this dissertation do not directly focus on these control variables, their inclusion in the models increases confidence in the interpretation of the findings involving the predictor variable coefficients used to test the hypotheses.

The findings showing a significant positive relationship between power plant size and power plant SO_2 emissions rates are consistent with the findings of Grant et al. (2002) that show a significant positive relationship between facility size and emissions rates in the chemical industry. These findings suggest that – at the facility level – big is indeed bad for the environment. However, the findings also suggest that other facility characteristics are more important than size.

This analysis shows that power plant age is more important than size. The positive relationship between power plant SO_2 emissions rates and power plant age is significant at the most stringent level of significance in every model. These findings are consistent with the criticisms advanced by many environmentalists and public health advocates who focus attention on the New Source Review exemptions to the Clean Air Act that allow older facilities to avoid pollution abatement upgrades. In addition, these findings are consistent with the structural inertia arguments that indicate age and size are impediments to change (Hannan and Freeman 1984). Such arguments suggest that – even if managers want to abate pollution – structural inertia makes the necessary technological upgrades more difficult to implement at older and larger facilities than at newer and smaller facilities.

The analysis also shows that the slope of the relationship between power plant age and power plant SO_2 emissions rates is the only slope that varies significantly across corporations and thus the only slope for which a variance component must be included in the random effects portion of the multilevel models. As discussed in Chapter II, this is methodologically crucial because failure to include random effects parameters for intercepts and slopes that vary significantly across level-2 units (i.e., corporations) can alter the fixed effects coefficients used to test the hypotheses. Including a random effects parameter for this significantly varying slope therefore increases confidence in the interpretation of how the corporate and community characteristics relate to the power plant SO_2 emissions rates. This exemplifies the advantages of using multilevel modeling to conduct the analysis.

The analysis of standard fixed effects coefficients also indicates that the control variable for facility fuel mix is important. As expected, the findings show a positive relationship between power plant SO_2 emissions rates and percent coal generation. These findings are consistent with much scientific research that indicates, all else equal, coal is the fossil fuel most responsible for air pollution emitted by power plants.

Lastly, there is limited evidence indicating that the cogeneration facility variable and the local population density variable are significantly related to power plant SO_2 emissions rates. These two control variables are significant in the model that includes corporate size as the only corporate characteristic and uses census tracts as the geo unit of analysis[33]. Even using census tracts, however,

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[33] The insignificance of the cogeneration dummy variable in most models is not surprising given the methodology used by the NRDC to measure emissions. As mentioned in Chapter III, the NRDC adjusts the emissions data for cogeneration facilities that produce a combination of electricity and steam or some other useful form of energy. The NRDC bases its emissions data

these variables lose significance when the total subsidiary and dividend payment variables are included in the analysis at the corporate level. In other words, the relationships involving these two control variables and power plant SO_2 emissions rates are contingent on the corporate characteristics. These findings suggest that there really is no causal connection directly linking either of these two control variables to power plant SO_2 emissions rates.

Further interpretation of these two control variables must proceed with caution because Appendix B shows that the findings differ when the analysis drops the cases that use adjoining zip codes and census tracts for power plants located in areas without demographic data. The tables in Appendix B indicating that the cogeneration variable is significant in all models using census tracts and that local population density variable is significant in all models using zip codes warrant the inclusion of these control variables in the analysis, but also suggest that their significance is unstable and contingent on many factors. For example, population density is included to control for multiple land-use factors involving urbanization and the clustering of industry, housing, transportation, and other activities in high-density areas. While it is not surprising that findings involving population density differ when the analysis drops facilities located in zip codes and census tracts that have no demographic data, it is difficult to attribute the

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only on emissions associated with electricity generation. This makes the emissions rates for the cogeneration facilities more comparable to the emissions rates for other facilities in the analysis.

differences to any one specific land use activity associated with population density. The important point for this dissertation is that dropping the power plants located in the low population density areas does not affect the conclusions drawn from testing of the corporate and community hypotheses.

In sum, the findings involving the control variables in this analysis move beyond previous research. Ecostructural theorists who focus their primary attention on explaining emissions rates at the facility level have not included facility age and fuel mix in their analyses. The analysis here shows that both these control variables are significant at the most stringent level of significance in every model. These findings suggest that ecostructural researchers must include these two variables in future studies that explain facility emissions rates. These findings also suggest that policy makers must establish a regulatory framework to encourage investments in new power plants that use natural gas instead of coal to generate electricity. The first priority should be eliminating the New Source review exemptions to the Clean Air Act that allow corporate power producers to avoid pollution abatement upgrades at old coal-fired power plants.

CONCLUSION

There are two general contributions of this research. First, it draws from ecostructural theory to examine corporate characteristics as determinants of pollution. Previous research shows that structural and financial characteristics involving the multilayer-subsidiary form and the shareholder conception of value explain rates of emissions that are aggregated up to the ultimate parent company (Prechel forthcoming). This multilevel examination demonstrates that the total number of subsidiaries in the corporate structure and the dividend payments to shareholders explain emissions rates at the facilities where pollution is actually emitted and where potential investments in pollution abatement would take place. These findings substantiate the argument that the dependencies, incentives, and opportunities created by multilayer-subsidiary form and the associated changes in corporate financing allow and encourage managers to externalize pollution costs rather than improve on ecoefficiency by investing in pollution abatement technologies.

Second, the examination of the local communities draws from environmental justice scholars and other researchers in the environmental sociology and social movement literature to include several demographic characteristics and one local organizational variable. Consistent with the literature, the findings involving racial composition and other demographic characteristics are contingent on the geographic unit of analysis. Hence, the demographic analysis fails to provide consistent support for any model of environmental inequality. Nonetheless, the findings involving the local organizational variable support the path of least resistance theory that underpins the sociopolitical model. The significant negative relationship between the number of local non-profit organizations and power plant SO_2 emissions rates is consistent with ecostructural theory (Grant et al. 2004), which recognizes the effects that social-structural characteristics of local communities can have on environmental pollution.

This multilevel framework demonstrates that theoretical insights from several different lines of environmental research can be brought together and tested simultaneously. This is important because it shows that both levels of social structure explain environmental pollution. Future research can use the multilevel framework established here to explain other types of pollutants (e.g., nitrogen oxides) emitted by facilities in the electrical power industry and other high-polluting industries.

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APPENDIX A

OLS REGRESSION ESTIMATES OF CORPORATE AND LOCAL COMMUNITY CHARACTERISTICS ON POWER PLANT SO_2 EMISSIONS RATES

Table A.1. OLS Regression Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: ZIP Codes for Community Variables

	Model 1	Model 2	Model 3
Main Fixed Effects			
Intercept	-4.4730 ***	-4.7988 ***	-5.2281 ***
	[.7508]	[.7540]	[.7224]
Corporate Characteristics			
Total Assets	-.0004	-.0013 *	-.0012 *
(in $100 Million Dollars)	[.0007]	[.0007]	[.0007]
Total Number of Subsidiaries		.0082 *	.0081 *
		[.0040]	[.0039]
Dividends Paid Per Share		.3004 **	.2995 **
(in $Dollars)		[.1062]	[.1060]
Local Community Characteristics			
Community Percent Black	.0156 **	.0136 **	.0119 *
	[.0058]	[.0058]	[.0058]
Community Percent Families	-.0518 ***	-.0476 **	-.0650 ***
Living in Poverty	[.0160]	[.0160]	[.0192]
Community Percent Families			.0017
Living in Poverty Squared			[.0011]
Community Median Home Value	-.0113	-.0077	-.0123
(in $10 Thousand Dollars)	[.0186]	[.0187]	[.0189]
Total Number of Non-Profit	-.1353 *	-.1323 *	-.1517 *
Organizations in County (Log)	[.0685]	[.0684]	[.0693]
Power Plant and Local Controls			
Facility Megawatt Nameplate	.2213 **	.2005 *	.2065 *
Generating Capacity (Log)	[.0925]	[.0920]	[.0920]
Facility Age	.0410 ***	.0410 ***	.0413 ***
	[.0048]	[.0048]	[.0048]
Facility Percent Coal Generation	.0496 ***	.0492 ***	.0489 ***
	[.0022]	[.0022]	[.0022]
Cogeneration Facility	-.5044	-.3285	-.2769
	[.3590]	[.3615]	[.3623]
County Population Density (/100)	.0075 *	.0064	.0071 *
	[.0043]	[.0043]	[.0043]
Model Fit Statistics			
N =	536	536	536
F =	127.13 ***	108.55 ***	100.72 ***
R-Squared =	.7077	.7135	.7150
Adjusted R-Squared =	.7022	.7069	.7079

*** P<.001; ** P<.01; * P<.05 one-tail significance.

Table A.2. OLS Regression Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: Census Tracts for Community Variables

	Model 1a	Model 2a	Model 3a
Main Fixed Effects			
Intercept	-4.5585 ***	-4.8613 ***	-5.1594 ***
	[.7498]	[.7517]	[.7297]
Corporate Characteristics			
Total Assets	-.0002	-.0012	-.0012
(in $100 Million Dollars)	[.0007]	[.0007]	[.0007]
Total Number of Subsidiaries		.0089 *	.0090 *
		[.0040]	[.0040]
Dividends Paid Per Share		.3021 **	.3046 **
(in $Dollars)		[.1064]	[.1066]
Local Community Characteristics			
Community Percent Black	.0084	.0061	.0062
	[.0053]	[.0053]	[.0054]
Community Percent Families	-.0330 **	-.0298 **	-.0353 *
Living in Poverty	[.0127]	[.0126]	[.0171]
Community Percent Families			.0003
Living in Poverty Squared			[.0006]
Community Median Home Value	-.0276 *	-.0272*	-.0287 *
(in $10 Thousand Dollars)	[.0154]	[.0154]	[.0157]
Total Number of Non-Profit	-.1025	-.0975	-.0991
Organizations in County (Log)	[.0678]	[.0677]	[.0679]
Power Plant and Local Controls			
Facility Megawatt Nameplate	.2072 *	.1850 *	.1839 *
Generating Capacity (Log)	[.0936]	[.0931]	[.0932]
Facility Age	.0410 ***	.0411 ***	.0409 ***
	[.0048]	[.0048]	[.0048]
Facility Percent Coal Generation	.0495 ***	.0490 ***	.0490 ***
	[.0022]	[.0022]	[.0022]
Cogeneration Facility	-.5977 *	-.4219	-.4099
	[.3592]	[.3613]	[.3625]
County Population Density (/100)	.0097 *	.0087 *	.0085 *
	[.0044]	[.0044]	[.0044]
Model Fit Statistics			
N =	536	536	536
F =	125.61 ***	107.42 **	99.03 ***
R-Squared =	.7052	.7114	.7115
Adjusted R-Squared =	.6996	.7048	.7043

*** P<.001; ** P<.01; * P<.05 one-tail significance.

APPENDIX B

MIXED-EFFECTS ESTIMATES OF CORPORATE AND LOCAL COMMUNITY CHARACTERISTICS ON FACILITY SO_2 EMISSIONS RATES: REDUCED STUDY GROUP FOR PROBLEMATIC ZIP CODES AND CENSUS TRACTS

Table B.1. Mixed-Effects Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: ZIP Codes for Community Variables

	Model 1	Model 2	Model 3
Fixed Effects			
Intercept	-3.8274 ***	-4.3030 ***	-4.6446 ***
	[.7520]	[.7552]	[.7294]
Corporate Characteristics			
Total Assets	.0005	-.0008	-.0008
(in $100 Million Dollars)	[.0009]	[.0009]	[.0009]
Total Number of Subsidiaries		.0131 **	.0131 **
		[.0051]	[.0051]
Dividends Paid Per Share		.3221 **	.3286 **
(in $Dollars)		[.1228]	[.1226]
Local Community Characteristics			
Community Percent Black	.0128 *	.0120 *	.0097 *
	[.0059]	[.0060]	[.0059]
Community Percent Families	-.0433 **	-.0412 **	-.0607 ***
Living in Poverty	[.0159]	[.0158]	[.0188]
Community Percent Families			.0019 *
Living in Poverty Squared			[.0010]
Community Median Home Value	-.0135	-.0111	-.0163
(in $10 Thousand Dollars)	[.0187]	[.0186]	[.0188]
Total Number of Non-Profit	-.1986 **	-.1998 **	-.2218 ***
Organizations in County (Log)	[.0680]	[.0675]	[.0683]
Power Plant and Local Controls			
Facility Megawatt Nameplate	.1475	.1371	.1413
Generating Capacity (Log)	[.0927]	[.0916]	[.0913]
Facility Age	.0400 ***	.0404 ***	.0406 ***
	[.0056]	[.0055]	[.0055]
Facility Percent Coal Generation	.0494 ***	.0488 ***	.0486 ***
	[.0023]	[.0022]	[.0022]
Cogeneration Facility	-.6064 *	-.4719	-.4063
	[.3473]	[.3476]	[.3480]
County Population Density (/100)	.0109 **	.0103 *	.0112 **
	[.0046]	[.0045]	[.0045]
Random Effects Parameters			
Variance (Facility Age)	.0003 ***	.0003 ***	.0003 ***
	[.0001]	[.0001]	[.0001]
Variance (Constant)	.0356	.0000009	.0000004
	[.0693]	[.0002]	[.0001]
Variance (Level-1 Residual)	3.1754	3.1337	3.1090
	[.2123]	[.2072]	[.2053]
Model Fit Statistics			
Wald Chi2	993.05 ***	1169.56 ***	1077.59 ***
AIC	2097.13	2089.96	2088.37
BIC	2156.36	2157.64	2160.29
N Level-2	51	51	51
N Level-1	508	508	508

*** P<.001; ** P<.01; * P<.05 one-tail significance reported for fixed effects.
One-tail LR Chi2 significance reported for random effect variance components (facility age and constant) and Wald model fit statistic.

Table B.2. Mixed-Effects Estimates of Corporate and Local Community Characteristics on Facility SO_2 Emissions Rates: Census Tracts for Community Variables

	Model 1a	Model 2a	Model 3a
Fixed Effects			
Intercept	-4.2422 ***	-4.6574 ***	-4.8479 ***
	[.7528]	[.7548]	[.7351]
Corporate Characteristics			
Total Assets	.0005	-.0007	-.0007
(in $100 Million Dollars)	[.0009]	[.0009]	[.0009]
Total Number of Subsidiaries		.0124 **	.0125 **
		[.0049]	[.0049]
Dividends Paid Per Share		.3167 **	.3188 **
(in $Dollars)		[.1221]	[.1222]
Local Community Characteristics			
Community Percent Black	.0064	.0048	.0051
	[.0054]	[.0054]	[.0054]
Community Percent Families	-.0239 *	-.0211 *	-.0311 *
Living in Poverty	[.0127]	[.0126]	[.0170]
Community Percent Families			.0005
Living in Poverty Squared			[.0005]
Community Median Home Value	-.0298 *	-.0283 *	-.0311 *
(in $10 Thousand Dollars)	[.0158]	[.0157]	[.0160]
Total Number of Non-Profit	-.1499 *	-.1453 *	-.1486 *
Organizations in County (Log)	[.0679]	[.0675]	[.0675]
Power Plant and Local Controls			
Facility Megawatt Nameplate	.1827 *	.1645 *	.1623 *
Generating Capacity (Log)	[.0931]	[.0923]	[.0922]
Facility Age	.0410 ***	.0407 ***	.0405 ***
	[.0055]	[.0054]	[.0054]
Facility Percent Coal Generation	.0487 ***	.0481 ***	.0482 ***
	[.0023]	[.0022]	[.0022]
Cogeneration Facility	-.8957 **	-.7711 *	-.7532 *
	[.3540]	[.3546]	[.3549]
County Population Density (/100)	.0063	.0055	.0050
	[.0049]	[.0049]	[.0049]
Random Effects Parameters			
Variance (Facility Age)	.0002 **	.0002 ***	.0002 ***
	[.0001]	[.0001]	[.0001]
Variance (Constant)	.0235	.0000001	.0000001
	[.0749]	[.00004]	[.]
Variance (Level-1 Residual)	3.3696	3.3231	3.3162
	[.2110]	[.2147]	[.2142]
Model Fit Statistics			
Wald Chi2	1005.76 ***	1076.13 ***	1076.18 ***
AIC	2194.03	2187.00	2186.23
BIC	2253.74	2255.25	2254.47
N Level-2	50	50	50
N Level-1	526	526	526

*** P<.001; ** P<.01; * P<.05 one-tail significance reported for fixed effects.
One-tail LR Chi2 significance reported for random effect variance components (facility age and constant) and Wald model fit statistic.

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